



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

HME 0612

DOES NOT CIRCULATE

HARVARD UNIVERSITY.



LIBRARY

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

8086

Exchange

July 22, 1921.

8086

BULLETIN
OF
THE AMERICAN MUSEUM
OF NATURAL HISTORY

VOLUME XLII, 1920



NEW YORK
PUBLISHED BY ORDER OF THE TRUSTEES
1920

EDITED BY FRANK E. LUTZ

THE AMERICAN MUSEUM OF NATURAL HISTORY
SEVENTY-SEVENTH STREET AND CENTRAL PARK WEST, NEW YORK CITY

BOARD OF TRUSTEES
(As of December 31, 1920)

PRESIDENT
HENRY FAIRFIELD OSBORN

FIRST VICE-PRESIDENT
CLEVELAND H. DODGE

SECOND VICE-PRESIDENT
J. P. MORGAN

TREASURER
HENRY P. DAVISON

SECRETARY
ADRIAN ISELIN

EX-OFFICIO
THE MAYOR OF THE CITY OF NEW YORK
THE COMPTROLLER OF THE CITY OF NEW YORK
THE PRESIDENT OF THE DEPARTMENT OF PARKS

ELECTIVE
GEORGE F. BAKER
FREDERICK F. BREWSTER
THOMAS DEWITT CUYLER
WALTER DOUGLAS
CHILDS FRICK
MADISON GRANT
WILLIAM AVERELL HARRIMAN
ARCHER M. HUNTINGTON

ARTHUR CURTISS JAMES
WALTER B. JAMES
CHARLES LANIER
OGDEN MILLS
PERCY R. PYNE
THEODORE ROOSEVELT
JOHN B. TREVOR
FELIX M. WARBURG

ADMINISTRATIVE OFFICERS
(As of December 31, 1920)

DIRECTOR
FREDERIC A. LUCAS

ASSISTANT SECRETARY
GEORGE H. SHERWOOD

ASSISTANT TREASURER
THE UNITED STATES TRUST COMPANY OF NEW YORK

SCIENTIFIC STAFF
(As of December 31, 1920)

FREDERICK A. LUCAS, Sc.D., Director

GEOLOGY AND INVERTEBRATE PALÆONTOLOGY

EDMUND OTIS HOVEY, Ph.D., Curator

CHESTER A. REEDS, Ph.D., Associate Curator [Invertebrate Palæontology]

MINERALOGY

HERBERT P. WHITLOCK, C.E., Curator

WOODS AND FORESTRY

MARY CYNTHIA DICKERSON, B.S., Curator

INVERTEBRATE ZOOLOGY

HENRY E. CRAMPTON, Ph.D., Curator

ROY W. MINER, A.B., Associate Curator

FRANK E. LUTZ, Ph. D., Associate Curator

A. J. MUTCHLER, Assistant

WILLARD G. VAN NAME, Ph.D., Assistant

FRANK E. WATSON, B.S., Assistant

JOSEPH BEQUAERT, Ph.D., Assistant in Congo Zoology

ICHTHYOLOGY AND HERPETOLOGY

BASHFORD DEAN, Ph.D., Honorary Curator

JOHN T. NICHOLS, A.B., Associate Curator of Recent Fishes

MARY CYNTHIA DICKERSON, B.S., Curator of Herpetology

G. K. NOBLE, A.M., Assistant Curator of Herpetology

MAMMALOGY AND ORNITHOLOGY

J. A. ALLEN, Ph.D., Curator

FRANK M. CHAPMAN, Sc.D., Curator of Ornithology

ROY C. ANDREWS, A.M., Associate Curator of Mammalogy

W. DEW. MILLER, Associate Curator of Ornithology

H. E. ANTHONY, A.M., Associate Curator of Mammalogy

HERBERT LANG, Assistant Curator of Mammalogy

JAMES P. CHAPIN, A.M., Assistant in Ornithology

LUDLOW GRISCOM, A.M., Assistant

WILLIAM PERCY, Field Associate

VERTEBRATE PALÆONTOLOGY

HENRY FAIRFIELD OSBORN, LL.D., Sc.D., Honorary Curator

W. D. MATTHEW, Ph.D., Curator

WALTER GRANGER, Associate Curator [Mammals]

BARNUM BROWN, A.B., Associate Curator [Reptiles]

WILLIAM K. GREGORY, Ph. D., Associate in Palæontology

Scientific Staff

ANTHROPOLOGY

CLARK WISSLER, Ph.D., Curator
PLINY E. GODDARD, Ph.D., Curator of Ethnology
ROBERT H. LOWIE, Ph.D., Associate Curator
HERBERT J. SPINDEN, Ph. D., Assistant Curator
N. C. NELSON, M.L., Assistant Curator
CHARLES W. MEAD, Assistant Curator
LOUIS R. SULLIVAN, A.M., Assistant Curator

ANATOMY AND PHYSIOLOGY

RALPH W. TOWER, Ph.D., Curator

PUBLIC HEALTH

CHARLES-EDWARD A. WINSLOW, M.A., D.P.H., Curator

PUBLIC EDUCATION

GEORGE H. SHERWOOD, A.M., Curator
G. CLYDE FISHER, Ph.D., Associate Curator
RUTH E. CROSBY, Assistant Curator

BOOKS AND PUBLICATIONS

RALPH W. TOWER, Ph.D., Curator
IDA RICHARDSON HOOD, A.B., Assistant Librarian

DEPARTMENT OF PREPARATION

LAURENCE V. COLEMAN, A.M., Chief

RESEARCH ASSOCIATES

M. D. C. CRAWFORD, Textiles, Anthropology
ALESSANDRO FABBRI, Physiology
GEORGE F. KUNZ, Ph.D., Mineralogy
CHARLES W. LENG, B.S., Coleoptera
J. HOWARD MCGREGOR, Ph.D., Anthropology
ROBERT CUSHMAN MURPHY, A.M., Ornithology
FRANK J. MEYERS, Rotifera
RAYMOND C. OSBURN, Ph.D., Bryozoa
A. L. TREADWELL, Ph.D., Annulata
WILLIAM M. WHEELER, Ph.D., Social Insects

CONTENTS OF VOLUME XLII

	PAGE
Title-page.....	i
Officers and Trustees.....	iii
Scientific Staff.....	iv
Contents.....	vi
Dates of Publication of Separates.....	vii
List of Illustrations.....	viii
List of New Taxonomic Names.....	xiii
Errata.....	xv
Art. I.—Studies on the Biology of the Aquatic Hydrophilidæ. By E. AVERY RICHMOND. (Plates I–XVI).....	1
II.—Studies in Comparative Myology and Osteology, No. IV. A Review of the Evolution of the Lacrymal Bone of Vertebrates with Special Reference to that of Mammals. By W. K. GREGORY. (Plate XVII, one hundred and ninety-six text figures).....	95
III.—Studies in Comparative Myology and Osteology, No. V. On the Anatomy of the Preorbital Fossæ of Equidæ and other Ungulates. By W. K. GREGORY. (Plate XVIII, twenty-six text figures).....	265
IV.— <i>Hynnys</i> and <i>Alectis</i> in The American Museum of Natural History. By JOHN TREADWELL NICHOLS. (Plate XIX).....	285
V.—New Species and Synonymy of American Cynipidæ. By ALFRED C. KINSEY. (Plates XX–XXVII).....	293
VI.—Life Histories of American Cynipidæ. By ALFRED C. KINSEY. (Plates XXVIII–XXXI).....	319
VII.—Phylogeny of Cynipid Genera and Biological Characteristics. By ALFRED C. KINSEY. (Plate XXXII, one text figure).....	357a
VIII.—Additions to the Ant Fauna of the West Indies and Central America. By WILLIAM M. MANN. (Ten text figures).....	403
IX.—Two New Batrachians from Colombia. By G. K. NOBLE.....	441
X.—Notes on American Lepidoptera with Descriptions of New Varieties. By FRANK W. WATSON and WM. P. COMSTOCK.....	447
XI.—Some Neotropical Bees. By T. D. A. COCKERELL.....	459
XII.—New Mammals from Jamaica. By H. E. ANTHONY. (Plate XXXIII, four text figures).....	469
XIII.—A Key to the Species of <i>Trachurus</i> . By JOHN TREADWELL NICHOLS.....	477
XIV.—Report on the Lepidoptera of the American Museum Expedition to Arizona, 1916. By WM. S. WRIGHT.....	483
XV.—Notes on the Distribution and Bibliography of North American Bees of the Families Apidæ, Meliponidæ, Bombidæ, Euglossidæ, and Anthophoridæ. By FRANK E. LUTZ and T. D. A. COCKERELL.....	491
XVI.—The Jurassic Ammonite Fauna of Cuba. By MARJORIE O'CONNELL. (Plates XXXIV–XXXVIII, eight text figures).....	643
XVII.—Staphylinidæ from Florida in the Collection of The American Museum of Natural History, with Descriptions of New Genera and Species. By HOWARD NOTMAN. (Plate XXXIX).....	693
Index.....	733

DATES OF PUBLICATION OF SEPARATES

The edition of separates is 300 copies, of which about 100 are mailed on the date of issue, and the others placed on sale in the Library.

Art.	I, Sept. 27, 1920.	Art.	X, Dec. 8, 1920.
"	II, Dec. 4, 1920.	"	XI, " 8, 1920.
"	III, " 4, 1920.	"	XII, " 11, 1920.
"	IV, " 10, 1920.	"	XIII, " 10, 1920.
"	V, " 20, 1920.	"	XIV, " 6, 1920.
"	VI, " 20, 1920.	"	XV, " 8, 1920.
"	VII, " 20, 1920.	"	XVI, " 14, 1920.
"	VIII, " 20, 1920.	"	XVII, " 15, 1920.
"	IX, " 8, 1920.		

LIST OF ILLUSTRATIONS

PLATES

- I.—Labium, head without appendages, and open stigmatic atrium of *Hydrophilus obtusatus*; egg-case and side view of caudal end of *Hydrobius fuscipes* larva; mandible of larva of *Ochthebius* type; maxilla of specialized type of Hydrophilid larva; side view of last three segments of *Hydrous triangularis* larva; and stigmatic atrium of *Philydrus nebulosus* larva.
- II.—*Helophorus lacustris*: mandible, maxilla, antenna, anterior part of head, mesothoracic leg, and labium of first-stage larva; dorsal view of larva, first stage, and egg-case.
- III.—*Ochthebius tuberculatus*: labium, labrum and clypeus, mandible, maxilla, mesothoracic leg, caudal end of anal segment, and antenna of first-stage larva; egg with loose covering of silk and larva, first stage.
- IV.—*Hydræna pennsylvanica*: labium, labrum and clypeus, antenna, mandible, maxilla, and mesothoracic leg of first-stage larva; egg-case, showing egg within, and first-stage larva.
- V.—*Hydrochous squamifer*: mandible, maxilla, head, antenna, and mesothoracic leg of first-stage larva; egg-case, enclosing the single egg.
- VI.—*Hydrophilus obtusatus*: mandible, maxilla, mesothoracic leg, labium, anterior region of head, and antenna of first-stage larva; egg-case and full-grown larva.
- VII.—*Tropisternus glaber*: mandible, maxilla, mesothoracic leg, antenna, anterior region of head, and labium of first-stage larva; egg-case and full-grown larva.
- VIII.—*Hydrous triangularis*: mandible, maxilla, mesothoracic leg, antenna, head without appendages, and labium of first-stage larva; motory stylus of pupa; egg-case and full-grown larva.
- IX.—*Laccobius agilis*: mandible, extremity of pupa, antenna, mesothoracic leg, maxilla, anterior region of head, and labium of first-stage larva; full-grown larva and egg-case.
- X.—*Berosus peregrinus*: mandible, maxilla, mesothoracic leg, pleural lobe of thorax, antenna, anterior part of head, and labium of first-stage larva; full-grown larva and egg-case.
- XI.—*Hydrobius globosus*: mandible, maxilla, mesothoracic leg, labium, antenna, and anterior region of head of first-stage larva; egg-case and full-grown larva.
- XII.—*Cymbiodyta fimbriata*: mandible, maxilla, mesothoracic leg, antenna, labium, and anterior region of head of first-stage larva; full-grown larva and caudal end of pupa.
- XIII.—*Helochares maculicollis*: mandible, maxilla, antenna, mesothoracic leg, labium, and anterior region of head of first-stage larva; full-grown larva and egg-case.
- XIV.—*Philydrus perplexus*: mandible, maxilla, antenna, mesothoracic leg, labium, and anterior region of head of first-stage larva; full-grown larva and egg-case. Egg-case of *Philydrus ochraceus*.
- XV.—*Ancæna infuscata*: mandible, maxilla, antenna, mesothoracic leg, anterior margin of head, and labium of first-stage larva; full-grown larva and egg-case.
- XVI.—*Paracymus subcupreus*: mandible, maxilla, antenna, anterior region of head, mesothoracic leg, and labium of first-stage larva; full-grown larva.
- XVII.—Evolution of the lacrymal bone from fish to primitive mammal and from primitive primate to man.

- XVIII.—Skulls of various recent and extinct Equidæ with semidiagrammatic reconstructions, showing, in the extinct forms, the supposed backward extension of the nasal diverticulum into the "lacrymal" fossa and the positions of the maxillo-labialis superior and other muscles.
- XIX.—*Hynnis cubensis*, 31 in. long to base of caudal. From a mounted specimen from Florida.
- XX.—Galls of *Andricus punctatus* and *Aulacidea annulata*.
- XXI.—Galls of the new species *Aulacidea abdita*, *Neuroterus thompsoni*, and *Diastrophus tumefactus*.
- XXII–XXV.—Galls of the new species *Andricus concolorans*, *A. furnaceus*, *A. pellucidus*, *A. incomptus*, *A. marmoreus*, *A. mexicanus*, *A. peredurus*, and *A. tecturnarum*.
- XXVI, XXVII.—Galls of the new species *Disholcaspis plumbella*, *D. fungiformis*, *D. unicolor*, and *D. pruniformis*.
- XXVIII.—Galls of *Aylaz glechomæ*, *Rhodites rosæ*, and *R. ignotus*.
- XXIX.—Galls of *Neuroterus batatus* forms *bisexualis* and *batatus* and *Neuroterus noxiosus* forms *vernalis* and *noxiosus*.
- XXX.—Galls of *Neuroterus tectus tectus*, *Andricus palustris palustris*, *A. p. compressus*, *A. futilis radicola*, and *A. f. futilis*.
- XXXI.—Galls of *Andricus operator operator*, *A. o. operatorola*, *A. fulvicollis bicoloris*, and *A. f. erinacei*.
- XXXII.—Wing venation and abdominal characters of the Cynipidæ.
- XXXIII.—Mandible, upper and lower molars of *Clidomys osborni*; molars of *Clidomys parvus*, *Spirodonomys jamaicensis*, *Alterodon major*, and *Speoxenus cundalli*.
- XXXIV.—Views of *Perisphinctes cubanensis*, new species, and *P. cubanensis* mutation α , new mutation.
- XXXV.—Views of *Perisphinctes cubanensis* β , new mutation and *Perisphinctes delatorri*, new species.
- XXXVI.—Views of *Perisphinctes plicatiloides* and *Idoceras soteloï*, new species.
- XXXVII.—Views of *Ochetoceras canaliculatum burckhardti*, new variety.
- XXXVIII.—Views of *Ochetoceras mexicanum* and *Ataxioceras virgulatus*.
- XXXIX.—Maxilla of *Schistacme obtusa*, *Genosema sexualis*, *Hoplandria lateralis*, and *Eumicrota anomala*; labium, maxilla, intermesocoxal parts, and intermediate tarsus of *Elachistarthron ambiguum*; labium, maxilla, sixth dorsal abdominal segment of male, intermesocoxal parts, and intermediate tarsus of *Orthodialetus innotabilis*; sixth dorsal abdominal segment of male *Silusida tenuicornis*; labium and maxilla of *Lophomucter levicollis*.

TEXT FIGURES

PAGE

Side and dorsal view of head of a very primitive rhipidistian fish, <i>Osteolepis macrolepidotus</i>	111
Skulls of <i>Amia calva</i> , <i>Lepidosteus tristæchus</i> , <i>Tarpon atlanticus</i> , <i>Sphyræna barracuda</i> , and <i>Polypterus bichir</i>	112
Generalized stegoceph skull, showing location of sensory grooves; fore part of skull of <i>Micropholis stowi</i> , showing course of naso-lacrymal duct.....	113
Skulls of <i>Melanerpeton falax</i> and <i>Branchiosaurus amblystoma</i>	114

	PAGE
Skulls of various Stegocephs: <i>Trimerorhachis insignis</i> , <i>Siegops divaricata</i> , <i>Micropholis stowi</i> , <i>Bothriceps australis</i> , <i>Broiliellus texensus</i> , and <i>Diplocaulus megacephalus</i>	115
Skulls of Stegocephs: <i>Loxomma allmani</i> , <i>Archegosaurus latirostris</i> , <i>Eryops megacephalus</i> , and <i>Cyclotosaurus robustus</i>	116
Skulls of modern Urodeles showing loss of the lacrymal and retention of the prefrontal.....	117
Skulls of modern Anura: <i>Rana pipiens</i> and <i>Bufo ornatus</i>	118
Skulls of Cotylosaurs: <i>Seymouria baylorensis</i> , <i>Pantylus cordatus</i> , and <i>Pariasaurus</i>	120
Skulls of Cotylosaurs: <i>Seymouria baylorensis</i> , <i>Diadectes (Empedias) molaris</i> , <i>Labidosaurus</i> , <i>Limnoscelis paludis</i> , <i>Procolophon trigoniceps</i> , <i>Pantylus cordatus</i> , and <i>Pariasaurus</i>	121
Skull of <i>Chelone imbricata</i>	122
Skulls of Pelycosaurs: <i>Naosaurus claviger</i> , <i>Mycterosaurus longiceps</i> , and <i>Sphenacodon</i>	122
Two views of skull of <i>Alligator mississippiensis</i> and <i>Tyrannosaurus rex</i>	124
Skulls of a pseudosuchian (<i>Euparkeria</i>) and of typical ornithischian dinosaurs, showing the retraction of the lacrymal, the reduction of the antorbital fenestra, and the backward extension of the premaxilla in the Ornithischia.....	126
Skulls of various Sauropsida showing reduction or absence of the lacrymal and its replacement by the prefrontal.....	130
Skulls of <i>Dicynodon moschops</i> , <i>D. leoniceps</i> , and <i>Moschops capensis</i>	132
Skulls of <i>Scylacops capensis</i> , <i>Cynognathus berryi</i> , and <i>Ictidopsis elegans</i>	133
Skulls of <i>Tritylodon</i> and <i>Polymastodon</i>	138
Skulls of <i>Echidna</i> (= <i>Tachyglossus</i>) and <i>Ornithorhynchus</i>	139
Skulls of <i>Didelphis virginiana</i> , <i>Perameles</i> , and <i>Palæothentes intermedius</i>	140
Skulls of <i>Amphiproiverra</i> and <i>Borhyaena tuberosa</i>	141
Skulls of <i>Dasyurus viverrinus</i> , <i>Sarcophilus ursinus</i> , <i>Thylacinus cynocephalus</i> , and <i>Myrmecobius fasciatus</i>	142
Skulls of <i>Wynyardia bassiana</i> , <i>Macropus</i> , and <i>Phascalomys</i>	144
Skulls of <i>Deltatherium fundamini</i> and <i>Limnocyon potens</i>	146
Skulls of <i>Hyænodon paucidens</i> and <i>H. horridus</i>	147
Skulls of <i>Vulpavus profectus</i> , <i>Daphænus</i> , <i>Ælurus fulgens</i> , and <i>Ursus americanus</i>	149
Skulls of <i>Bassariscus astuta</i> , <i>Phlaocyon leucosteus</i> , and <i>Procyon hernandezi</i>	150
Skulls of Viverridæ.....	152
Skulls of Viverridæ.....	153
Skulls of Mustelidæ.....	154
Skulls of Mustelidæ.....	155
Skulls of <i>Eumetopias stelleri</i> and <i>Odobæus rosmarus</i>	157
Skulls of <i>Prozeuglodon atrox</i> , <i>Mesoplodon grayi</i> , and <i>Balaenoptera borealis</i>	159
Skulls of <i>Ictops dakotensis</i> , <i>Proterix loomisi</i> , <i>Gymnura rafflesi</i> , <i>Erinaceus (Atelerix) langi</i> and <i>E. europæus</i>	162
Skulls of <i>Centeles ecaudatus</i> , <i>Solenodon paradoxus</i> , and <i>Potamogale velox</i>	165
Skulls of <i>Onychodectes tisonensis</i> , <i>Stegotherium tessellatum</i> , <i>Dasypus sexcinctus</i> , <i>Tolypeutes conurus</i> , <i>Hapalops ruetemeyeri</i> , and <i>Bradypus</i>	167

Skulls of <i>Scelidotherium cuvieri</i> , <i>Myrmecophaga jubata</i> , <i>Tamandua tetradactyla</i> , and <i>Cyclopes dorsalis</i>	169
Skulls of <i>Manis</i> and <i>Orycteropus</i> species.....	170
Skulls of <i>Paramys copei</i> , <i>Arctomys</i> species, <i>Castor canadensis</i> , <i>Lophiomys imhausi</i> , <i>Pedetes caffer</i> , and <i>Hydrochærus capybara</i>	173
Skulls of <i>Hyopsodus despiciens</i> , <i>Phenacodus primævus</i> , <i>Meniscotherium chamense terrærubra</i> , and <i>Diadiaphorus</i> species.....	175
Skull of <i>Nesodon imbricatus</i>	177
Skulls of <i>Hegelotherium mirabile</i> , <i>Pachyrhinos moyani</i> , <i>Protypotherium australe</i> , and <i>Interatherium robustus</i>	179
Skulls of <i>Haploconus lineatus</i> and <i>Dinoceras mirabile</i>	181
Skulls of <i>Mærittherium lyonsi</i> , <i>Manatus latirostris</i> , and <i>Arsinoitherium zitteli</i>	182
Skulls of <i>Mastodon americanus</i> and <i>Elephas indicus</i>	183
Skulls of <i>Megalohyrax</i> and <i>Dendrohyrax</i> species.....	185
Skulls of <i>Dichobune leporina</i> , <i>Procamelus occidentalis</i> , <i>Tragulius</i> , <i>Dorcatherium</i> , and <i>Cervulus</i> species.....	187
Skulls of <i>Agriochærus trifrons</i> , <i>Oreodon culbertsonii periculorum</i> , and <i>Leptauchenia decora</i>	188
Skulls of <i>Eporeodon occidentalis pacificus</i> , <i>Promerycochærus</i> and <i>Merycochærus</i> species.....	189
Skulls of pig-like Artiodactyls: <i>Entelodon</i> , <i>Ancodon brachyrhynchus</i> , and <i>Hippopotamus lemerlei</i>	190
Skulls of <i>Perchærus pristinus</i> and <i>Dicotyles</i> (= <i>Tayassu</i>) <i>pecari</i>	191
Skulls of <i>Potamochoerus</i> and <i>Phacochoerus</i> species.....	192
Skulls of <i>Hyrachyus</i> , <i>Ceralotherium simum</i> , and <i>Tapirus terrestris</i>	194
Skulls of <i>Hyracodon nebrascensis</i> and <i>Cænopus</i> (= <i>Subhyracodon</i>) <i>trigonodus</i>	196
Skulls of <i>Manteoceras washakiensis</i> and <i>Metamynodon planifrons</i>	197
Skulls of <i>Tupaia</i> , <i>Rhynchocyon claudii</i> , <i>Elephantulus</i> (<i>Macroscelides</i>) species, and <i>Galeopithecus</i>	198
Skulls of <i>Notharctus osborni</i> , <i>Adapis parisiensis bruni</i> , <i>A. (Leptadapis) magnus</i> , <i>Megaladapis grandidieri</i> , and <i>Lemur mongoz</i>	201
Skulls of <i>Propithecus coquerelli</i> , <i>Archæolemur edwardsi</i> , and <i>Chiromys</i> (= <i>Daubentonina</i>) <i>madagascariensis</i>	203
Skulls of <i>Perodicticus potto</i> , <i>Galago elegantulus</i> , <i>Necrolemur antiquus</i> , <i>Tetonius</i> ("Anaplotomorphus") <i>homunculus</i> , and <i>Tarsius spectrum</i>	204
Skulls of <i>Alouatta</i> (<i>Myetes</i>) <i>beelzebul</i> , <i>Cacajao calvus</i> , <i>Chrysothrix</i> and <i>Troglo-dytes</i> (= <i>Pan</i>) species.....	210
Preorbital fossæ of various mammals: <i>Macropus</i> , <i>Rhynchocyon</i> , <i>Potamochoerus</i> , and <i>Dicotyles</i>	267
Facial muscles of ungulates: <i>Sus scrofa</i> , <i>Tapirus terrestris</i> , <i>Rhinoceros sumatrensis</i> , and <i>Equus caballus</i>	272
<i>Equus grevyi</i> : dissection of nasal diverticulum and view of skull, showing the "malar," "subnasal," and "buccinator" fossæ.....	274
Views of nasal diverticulum in <i>Equus asinus</i> , <i>Tapirus</i> (<i>Rhinocærus</i>) <i>indicus</i> , <i>Tapirus terrestris</i> , <i>Onohippidium muñizi</i> , and <i>Rhinoceros sumatrensis</i>	276
Views of skull and restorations of muscles of <i>Onohippidium muñizi</i>	277
Skull of <i>Astrapotherium</i> species, showing deep preorbital fossæ.....	278

	PAGE
<i>Metamynodon planifrons</i> . Skull, showing large preorbital fossa	279
Views of skulls of <i>Metamynodon planifrons</i> and <i>Amyndodon intermedius</i> showing preorbital fossa	280
Views of skulls of <i>Rhinoceros indicus</i> and <i>Ceratotherium simum</i> , showing shallow preorbital fossa	281
Diagrammatic tree showing relations of some cynipid genera	400
Side view of thorax and petiole of <i>Macromischa</i> (<i>Macromischa</i>) <i>purpurata</i>	411
Side view of thorax and petiole of <i>Macromischa</i> (<i>Macromischa</i>) <i>squamifera</i>	413
Side view of thorax and petiole of <i>Macromischa</i> (<i>Macromischa</i>) <i>allardycei</i>	415
Lateral view of <i>Macromischa</i> (<i>Macromischa</i>) <i>scabripes</i>	417
Side view of thorax and petiole of <i>Macromischa</i> (<i>Macromischa</i>) <i>affinis</i>	418
Side view of thorax and petiole of <i>Macromischa</i> (<i>Cræsomyrmez</i>) <i>wheeleri</i>	423
Side view of thorax and petiole of <i>Macromischa</i> (<i>Antillæmyrmex</i>) <i>terricola</i>	424
View of an orange tree, showing the protection against the "bibijagua" (<i>Atta insularis</i>)	429
Side view of head, thorax, and petiole of <i>Prenolepis</i> (<i>Prenolepis</i>) <i>gibberosa</i>	433
View of head and pronotum of <i>Camponotus</i> (<i>Colobopsis</i>) <i>sphaericus</i>	437
External view of left mandible of <i>Clidomys osborni</i> and crown views of mandibular molar series of <i>C. osborni</i> , <i>Elasmodontomys obliquus</i> , and <i>Amblyrhiza inundata</i>	470
Lower molar of <i>Clidomys osborni</i> and <i>C. parvus</i>	471
Upper molars of <i>Clidomys osborni</i> and <i>Speoxenus cundalli</i> ; upper and lower molars of <i>Spirodontomys jamaicensis</i>	474
Crown and lateral views of molar of <i>Alterodon major</i>	475
Diagrammatic sketch of the mode of development of costæ in the genus <i>Perisphinctes</i> , showing the origin of diad and triad groups and of intercalated costæ	647
Arrangement of costæ on the second volution of <i>Perisphinctes cubanensis</i> , showing grouping on either side of the third constriction	651
Arrangement of costæ at beginning of fourth volution of <i>Perisphinctes cubanensis</i> , showing increased complexity in grouping produced by repeated bifurcations	652
Arrangement of costæ on last quarter of fourth volution of <i>Perisphinctes cubanensis</i> , showing acceleration of costæ	653
Arrangement of costæ on last half of fifth volution of <i>Perisphinctes cubanensis</i> ..	654
Arrangement of the costæ on the first half of sixth volution of <i>Perisphinctes cubanensis</i> , showing adult costæ grouping	657
Tracing from the holotype of <i>Perisphinctes cubanensis</i> , showing the last costæ on the final whorl and the adult costal delimitation of the last constriction ..	657
Suture line of <i>Perisphinctes plicatiloides</i> , new species	678

LIST OF NEW TAXONOMIC NAMES IN THIS VOLUME

HIGHER GROUP

	PAGE
Elachistarthronini Notman.....	714

GENERA AND SUBGENERA

<i>Cræsomyrmez</i> Mann.....	408
<i>Antillæmyrmez</i> Mann.....	408
<i>Centrolenella</i> Noble.....	441
<i>Clidomys</i> Anthony.....	469
<i>Spirodontomys</i> Anthony.....	473
<i>Speozenus</i> Anthony.....	473
<i>Hallerodon</i> Anthony (See errata).....	474
<i>Ophioömma</i> Notman.....	704
<i>Schistacme</i> Notman.....	712
<i>Elachistarthron</i> Notman.....	715
<i>Orthodiatelus</i> Notman.....	716
<i>Genosema</i> Notman.....	720
<i>Lophomucler</i> Notman.....	722
<i>Omoschema</i> Notman.....	731

SPECIES AND SUBSPECIES

<i>Aulacidea abdita</i> Kinsey.....	296
<i>Aulacidea annulata</i> Kinsey.....	298
<i>Diastrophus tumefactus</i> Kinsey.....	299
<i>Neuroterus thompsoni</i> Kinsey.....	301
<i>Andricus concolorans</i> Kinsey.....	302
<i>Andricus furnaceus</i> Kinsey.....	304
<i>Andricus incomptus</i> Kinsey.....	306
<i>Andricus marmoreus</i> Kinsey.....	307
<i>Andricus mexicanus</i> Kinsey.....	308
<i>Andricus pellucidus</i> Kinsey.....	309
<i>Andricus peredurus</i> Kinsey.....	310
<i>Andricus tecturnarum</i> Kinsey.....	312
<i>Disholcaspis fungiformis</i> Kinsey.....	312
<i>Disholcaspis plumbella</i> Kinsey.....	314
<i>Disholcaspis pruniformis</i> Kinsey.....	315
<i>Disholcaspis unicolor</i> Kinsey.....	316
<i>Neuroterus batatus bisexualis</i> Kinsey.....	334
<i>Neuroterus noziosus vernalis</i> Kinsey.....	337
<i>Neuroterus tectus abundans</i> Kinsey.....	339
<i>Andricus fulvicollis bicolens</i> Kinsey.....	354
<i>Odontomachus hamatoda notata</i> Mann.....	404
<i>Odontomachus hamatoda insularis wheeleri</i> Mann.....	405
<i>Macromischa (Macromischa) squamifera atrinodis</i> Mann.....	412
<i>Macromischa (Macromischa) allardycei</i> Mann.....	414

	PAGE
<i>Macromischa (Macromischa) schwarzi</i> Mann.....	415
<i>Macromischa (Macromischa) scabripes</i> Mann.....	416
<i>Macromischa (Macromischa) affinis</i> Mann.....	417
<i>Macromischa (Macromischa) fuscata</i> Mann.....	420
<i>Macromischa (Macromischa) flavitarsis</i> Mann.....	420
<i>Macromischa (Crasomyrmex) wheeleri</i> Mann.....	422
<i>Macromischa (Antillamyrmex) terricola</i> Mann.....	423
<i>Crematogaster sanguinea atavista</i> Mann.....	425
<i>Crematogaster sanguinea sotolongoi</i> Mann.....	425
<i>Crematogaster victima cubaensis</i> Mann.....	425
<i>Pheidole cubaensis grayi</i> Mann.....	426
<i>Solenopsis corticalis binolata</i> Mann.....	428
<i>Solenopsis globularia desecheoensis</i> Mann.....	428
<i>Strumigenys eggersi cubaensis</i> Mann.....	430
<i>Prenolepis (Nylanderia) myops</i> Mann.....	432
<i>Prenolepis (Prenolepis) gibberosa rogeri</i> Mann.....	434
<i>Myrmelachista rogeri rubriceps</i> Mann.....	434
<i>Camponotus (Colobopsis) sphaericus cardini</i> Mann.....	438
<i>Camponotus (Colobopsis) gundlachi</i> Mann.....	438
<i>Camponotus (Colobopsis) culmicola haweisi</i> Mann.....	439
<i>Centrolenella antioquiensis</i> Noble.....	444
<i>Bufo rostratus</i> Noble.....	445
<i>Basilarchia floridensis halli</i> Watson and Comstock.....	449
<i>Strymon acadica acadica muskoka</i> Watson and Comstock.....	450
<i>Strymon acadica souhegan swetti</i> Watson and Comstock.....	450
<i>Strymon acadica coolinensis</i> Watson and Comstock.....	451
<i>Strymon acadica montanensis</i> Watson and Comstock.....	451
<i>Strymon sœpium chlorophora</i> Watson and Comstock.....	452
<i>Strymon sœpium provo</i> Watson and Comstock.....	452
<i>Incisalia polios davisii</i> Watson and Comstock.....	453
<i>Heodes zanthoides luctuosa</i> Watson and Comstock.....	453
<i>Heodes hypophlœas hypophlœas banksi</i> Watson and Comstock.....	454
<i>Philotes enoptes mojave</i> Watson and Comstock.....	455
<i>Philotes sonorensis sonoralba</i> Watson and Comstock.....	456
<i>Plebeius acmon labecula</i> Watson and Comstock.....	457
<i>Melipona fasciata cramptoni</i> Cockerell.....	459
<i>Melipona lateralis kangarumensis</i> Cockerell.....	461
<i>Trigona subgrisea</i> Cockerell.....	465
<i>Trigona pura</i> Cockerell.....	466
<i>Clidomys osborni</i> Anthony.....	469
<i>Clidomys parvus</i> Anthony.....	472
<i>Spirodonlomys jamaicensis</i> Anthony.....	473
<i>Hallerodon major</i> Anthony (See errata).....	474
<i>Trachurus lathamii</i> Nichols.....	479
<i>Trachurus mccullochi</i> Nichols.....	479
<i>Trachurus murphyi</i> Nichols.....	479
<i>Hydriomena clarki</i> Wright.....	485
<i>Euchlana lutzi</i> Wright.....	489

List of New Names

xv

	PAGE
<i>Perisphinctes cubanensis</i> O'Connell.....	648
<i>Perisphinctes cubanensis</i> α O'Connell.....	660
<i>Perisphinctes cubanensis</i> β O'Connell.....	662
<i>Perisphinctes delatorii</i> O'Connell.....	663
<i>Perisphinctes plicatiloides</i> O'Connell.....	670
<i>Ochetoceras canaliculatum burckhardti</i> O'Connell.....	681
<i>Trogophlæus maculicollis</i> Notman.....	693
<i>Trogophlæus basicornis</i> Notman.....	694
<i>Bledius nigriceps</i> Notman.....	696
<i>Bledius canaliculatus</i> Notman.....	698
<i>Osorius brevicornis</i> Notman.....	698
<i>Stenus teler</i> Notman.....	699
<i>Stenus lutzi</i> Notman.....	700
<i>Telaropeus nigriceps</i> Notman.....	702
<i>Sciocharis (Sciocharella) quadriceps</i> Notman.....	703
<i>Ophiommma rufa</i> Notman.....	705
<i>Myllæna cuneata</i> Notman.....	710
<i>Myllæna currax</i> Notman.....	710
<i>Schistacme obtusa</i> Notman.....	712
<i>Silusida tenuicornis</i> Notman.....	714
<i>Elachistarthron ambiguum</i> Notman.....	715
<i>Orthodiatelus innotabilis</i> Notman.....	716
<i>Eumicrota anomala</i> Notman.....	718
<i>Eumicrota insolita</i> Notman.....	719
<i>Genosema sexualis</i> Notman.....	721
<i>Lophomucter lævicollis</i> Notman.....	722
<i>Tinotus amplius</i> Notman.....	723
<i>Tinotus brunnipes</i> Notman.....	724
<i>Tinotus planulus</i> Notman.....	724
<i>Trichiusa ursina</i> Notman.....	725
<i>Atheta macrops</i> Notman.....	725
<i>Atheta (Hilara) fulviceps</i> Notman.....	726
<i>Acrotoma picescens</i> Notman.....	729
<i>Acrotoma hebeticornis</i> Notman.....	730
<i>Omoschema laticeps</i> Notman.....	732

ERRATA

Page 204, line 2 from bottom, for *Miozecebus* read *Miozecebus*.

" 223, line 14 from top, for Dissorophidæ read Dissorhophidæ.

" 225, line 12 from bottom, for Dissorophidæ read Dissorhophidæ.

" 286, footnote 3, for pp. 539-532 read 539-542.

" 288, footnote 2, for *Blephoris* read *Blepharis*.

" 380, under species, for form *operatolor* read form *operatola*.

" 407, line 7 from bottom, for "in is" read "is in."

" 427, bottom line, for Columbia read Colombia.

" 428, line 7 from bottom, for *Acromyremx* read *Acromyrmex*.

" 430, line 4 from top, for *Cryptocerys* read *Cryptocerus*.

" 431, line 14 from bottom, for *Brachymyrmes* read *Brachymyrmex*.

Page 474, line 7 from bottom. Due to an error in transliteration, the proposed generic name, *Alerodon*, should be emended to read *Hallerodon*.—H. E. Anthony.

“ 509, line 3 from top, read p. 272 after 1837.

“ 509, line 19 from bottom, for “Boisedale and Cape Breton Island (Leng) and Codroy (Gratacap), NEWFOUNDLAND” read “Boisedale, Cape Breton Island, NOVA SCOTIA; (Leng). Codroy, NEWFOUNDLAND; (Gratacap).”

“ 527, line 17 from top, for Cockerell and Porter, 1896 read Cockerell and Porter, 1899.

“ 582, top line, for *Anthophorides* read *Anthophoroides*.

BULLETIN

OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

VOLUME XLII, 1920

59.57, 63H

Article I.—STUDIES ON THE BIOLOGY OF THE AQUATIC HYDROPHILIDÆ

By E. AVERY RICHMOND

Plates I to XVI

CONTENTS

	PAGE
I. INTRODUCTION.....	3
Historical.....	3
Methods of Collecting.....	8
Methods of Rearing.....	9
II. LIFE HISTORY AND BIOLOGY.....	10
General Survey.....	10
Explanation of Terms Used.....	12
General Characters of the Family (Immature Stages).....	14
General Characters, Life History, and Biology of the Forms Studied.....	17
1. Helophorinæ.....	17
<i>Helophorus</i> (Pl. II).....	17
<i>H. lacustris</i>	18
<i>H. aquaticus</i>	20
2. Limnebiinæ.....	20
<i>Limnebius</i>	21
<i>L. discolor</i>	21
3. Hydræninæ.....	21
<i>Ochthebius</i> (Pl. III).....	21
<i>O. tuberculatus</i>	22
<i>Hydræna</i> (Pl. IV).....	24
<i>H. pennsylvanica</i>	24
4. Hydroscaphinæ.....	27
5. Hydrochoinæ.....	27
<i>Hydrochous</i> (Pl. V).....	27
<i>H. squamifer</i>	29

6. Sphercheinæ.....	30
7. Hydrophilinæ.....	31
<i>Hydrophilus</i> (Pl. VI).....	31
<i>H. obtusatus</i>	31
<i>Tropisternus</i> (Pl. VII).....	35
<i>T. glaber</i>	35
<i>T. sublaevis</i> ?.....	39
<i>Hydrous</i> (Pl. VIII).....	39
<i>H. triangularis</i>	40
8. Hydrobiinæ.....	42
<i>Laccobius</i> (Pl. IX).....	43
<i>L. agilis</i>	43
<i>Berosus</i> (Pl. X).....	47
<i>B. peregrinus</i>	48
<i>B. striatus</i>	51
<i>Chaetarthria</i>	51
<i>Hydrobius</i> (Pl. XI).....	51
<i>H. globosus</i>	52
<i>H. fuscipes</i>	55
<i>H. tessellatus</i>	55
<i>H. scabrosus</i>	55
<i>Helocombus</i>	56
<i>Cymbiodyta</i> (Pl. XII).....	56
<i>C. fimbriata</i>	57
<i>C. blanchardi</i>	61
<i>Helochares</i> (Pl. XIII).....	61
<i>H. maculicollis</i>	62
<i>H. normatus</i>	65
<i>Philydrus</i> (Pl. XIV).....	65
<i>P. perplexus</i>	67
<i>P. nebulosus</i>	69
<i>P. ochraceus</i>	70
<i>P. cinctus</i>	70
<i>P. hamiltoni</i>	70
<i>Ancæna</i> (Pl. XV).....	71
<i>A. infuscata</i>	71
<i>Paracymus</i> (Pl. XVI).....	74
<i>P. subcupreus</i>	74
9. Sphæridiinæ.....	77
III. PHYLOGENETIC CONSIDERATIONS.....	77
IV. KEYS.....	82
Egg-cases.....	82
Larvæ.....	83
Pupæ.....	87
V. LITERATURE.....	88

I.—INTRODUCTION

In this country very little attention has been devoted to the biology of the water beetles of the family Hydrophilidæ, and there exists a woe-ful lack of knowledge concerning the immature stages. A general survey of the aquatic members of the family was begun by the author in the spring of 1914 and has been continued until the present time. Primarily the New York State species, especially those occurring in the vicinity of Ithaca, have been dealt with but the collection of the United States National Museum (which consists mostly of European material) has also been examined. All the genera here discussed have been reared by the author. Some specimens of the genus *Hydrous* were furnished through the courtesy of Dr. Robert Matheson of Cornell University. Throughout this paper the classification as given by the European authors has been maintained as far as advisable, the grouping in use in this country not having been influenced by the recent work of foreign authors.

For help toward the completion of this paper, I am greatly indebted to the following men: Dr. J. G. Needham, who personally directed this work; Mr. F. E. Wintersteiner, who so willingly helped in the identification of the adults; Dr. Adam Böving of the United States National Museum, who gave valuable suggestions in regard to the larvæ, descriptions and drawings; and Dr. L. O. Howard, who kindly placed the specimens of the United States National Museum at my disposal.

A set of the material upon which this paper is based is deposited in The American Museum of Natural History.

HISTORICAL

The Hydrophilidæ as a distinct group was first recognized by Latreille¹ when, in 1804, he applied the name Sphæridiota to this family. The earliest data found concerning the biology pertain to the genera *Hydrous* and *Hydrophilus*. This was presented respectively by Frisch in 1721 and Roesel in 1749. Until the middle of the nineteenth century very little was added; and it was not until Schiödte's Monograph in 1861 that any collected work of note appeared.

The little work that has been done in this country upon the natural history of this group of beetles consists only of scattered observations on the larger species. Life histories of American forms have been con-

¹Latreille, 1804, Hist. Nat. Crust. Ins., X, Ann. XII, p. 48.

tributed by Garman, Riley, and Matheson on *Hydrous triangularis*; by Wickham on *Tropisternus glaber*; by Wickham and Bowditch on *Hydrocharis obtusatus*; and by Böving on *Hydroscapha natans*.

In Europe there has been more activity. The work of Schiödte, 1861-1872, stands foremost and his results have been well supplemented by that of Balfour-Browne, Megusar, Miall, Planet, Duges, Reitter, Ganglbauer, and d'Orchymont. Schlick, Wesenberg-Lund, and Böving in Denmark have reared much important material, most of which has, through the efforts of Dr. Böving, been deposited in the National Museum at Washington. They have, however, published very little of their results.

The most valuable papers of today are those of Ganglbauer and d'Orchymont. The former's paper gives a lengthy survey of the family, based on the life histories as well as on adult structures. The latter's work presents new life histories in a number of genera, careful descriptions and figures, a discussion of the larval breathing apparatus, and a generic key to the known larvæ. Balfour-Browne has given the most complete treatise on any one species. He treats the entire life history of *Hydrobius fuscipes* from egg to adult, describing each stage and its biology in full and accompanies the whole with excellent figures.

It seems advisable to mention only the most important authors at this point. The others will be considered under the biology of the separate genera.

Table of known life histories of aquatic Hydrophilidæ
(*American genera*)

NAME	EGG	LARVA	PUPA	INVESTIGATOR	COUNTRY DATE
<i>Helophorus</i>					
1. <i>aquaticus</i> Linn.	*	*	*	Schiödte	Denmark, 1862
2. <i>granularis</i> Linn.	*	*	*	Schiödte	Denmark, 1862
3. <i>rufipes</i> Bosc.		*		Perris	France, 1876
4. <i>viridicollis</i> Steph.			Incomplete	Zambeu	France, 1894
5. <i>schmidtii</i> Villa			*	Zambeu	France, 1894
6. <i>micans</i> Fald.		*		Ganglbauer	Austria, 1904
7. <i>lacustris</i> Lec.	*	*		Author	United States, this paper
8. sp. ?	*	*		Author	United States, this paper
<i>Limnebius</i>					
1. <i>truncatellus</i> Thunbg.	*	*	Noted but not desc.	d'Orchymont	France, 1915
2. <i>discolor</i> Casey	*	*		Author (descr. in part)	United States, this paper
<i>Ochthebius</i>					
1. <i>punctatus</i> Steph.		*		Haliday	England, 1856
2. <i>subinteger</i> Muls.- Rey, subsp. <i>le-</i> <i>jolisi</i> Muls.-Rey		*		{ Mulsant-Rey Fauvel d'Orchymont	France, 1861 France, 1865 France, 1913
3. <i>quadricollis</i> Muls.		*		Ray	France, 1887
4. <i>impressus</i> Marsh.			Noted but not desc.	d'Orchymont	France, 1913
5. <i>steinbuehleri</i> Reitt		*		d'Orchymont	France, 1913
6. <i>tuberculatus</i> Lec.	*	*		Author	United States, this paper
7. sp. ?	*	*		Author	United States, this paper

*Table of known life histories of aquatic Hydrophilidæ
(American genera)*

NAME	EGG	LARVA	PUPA	INVESTIGATOR	COUNTRY DATE
<i>Hydræna</i> 1. <i>pennsylvanica</i> Kiesw.	*	*		Author	United States, this paper
<i>Hydroscaapha</i> 1. <i>natans</i> Lec.	*	*	*	Böving	United States, 1914
<i>Hydrochous</i> 1. <i>squamifer</i> Lec.	*	*		Author	United States, this paper
<i>Hydrophilus</i> 1. <i>caraboides</i> Linn. 2. <i>obtusatus</i> Say	 * * * *	 * * * *	 * * * *	{ Roesel Lyonnet Schiödte Bowditch Wickham Author	Germany, 1749 France, 1832 Denmark, 1862 Mass., 1884 Iowa, 1895 New York, this paper
<i>Tropisternus</i> 1. <i>lateralis</i> Fabr. 2. <i>glaber</i> Herbst	 *	 * * *	 * * *	Duges Wickham Author	Mexico, 1884 United States, (Iowa), 1893 United States, this paper
<i>Hydrous</i> 1. <i>piceus</i> Linn. 2. <i>aterrimus</i> Eschsch 3. <i>triangularis</i> Say	 * * * *	 * * * *	 * *	Miger Schiödte { Garman Riley	France, 1809 Denmark, 1862 United States, 1881 United States, 1881

*Table of known life histories of aquatic Hydrophilidæ
(American genera)*

NAME	EGG	LARVA	PUPA	INVESTIGATOR	COUNTRY DATE
<i>Berosus</i>					
1. <i>spinosus</i> Stev.	*	*	*	Schiödte	Denmark, 1862
2. <i>signaticollis</i> Charp.	*	*		{ Schiödte	Denmark, 1872
3. <i>striatus</i> Say	*	*		{ Brocher Author	France, 1911 United States, this paper
4. <i>peregrinus</i> Herbst	*	*		Author	United States, this paper
<i>Laccobius</i>					
1. sp. ?		*		d'Orchymont	France, 1913
2. <i>agilis</i> Randall	*	*	*	Author	United States, this paper
<i>Ancæna</i>					
1. <i>limbata</i> Fabr.		*		d'Orchymont	France, 1913
2. <i>infuscata</i> Motsch.	*	*		Author	United States, this paper
<i>Paracymus</i>					
1. <i>æneus</i> Germ.			Incomplete	Zamheu	France, 1894
2. <i>subcupreus</i> Say	*	*	*	Author	United States, this paper
<i>Hydrobius</i>					
1. <i>fuscipes</i> Linn.	* *	* *		Cussac Schiödte	France, 1855 Denmark, 1862
2. <i>globosus</i> Say	* *	* *	Incomplete	Balfour-Browne Author	England, 1910 United States, this paper
<i>Chatarthria</i>					
1. <i>atra</i> Le Conte	Undescribed.				

Table of known life histories of aquatic Hydrophilidæ
(American genera)

NAME	EGG	LARVA	PUPA	INVESTIGATOR	COUNTRY DATE
<i>Helochares</i>					
1. <i>lividus</i> Forst.	*	*	Incomplete	{ Cussac Schiödte	France, 1852 Denmark, 1862
2. <i>maculicollis</i> Muls.	*	*	*	Author	United States, this paper
<i>Cymbiodyta</i>					
1. <i>fimbriata</i> Melsh.	*	*	*	Author	United States, this paper
2. <i>blanchardi</i> Horn	*	*	*	Author	United States, this paper
<i>Helocombus</i>					
1. <i>bifidus</i> Lec.	Undescribed.				
<i>Philydrus</i>					
1. <i>testaceus</i> Fabr.	*	*	*	Schiödte	Denmark, 1862
2. <i>perplexus</i> Lec.	*	*	*	Author	United States, this paper
3. <i>nebulosus</i> Say	*	*	*	Author	United States, this paper
4. <i>ochraceus</i> Melsh.	*	*		Author	United States, this paper
5. <i>cinctus</i> Say	*	*		Author	United States, this paper
6. <i>hamiltoni</i> Horn	*	*		Author	United States, this paper

METHODS OF COLLECTING

The majority of these beetles live at the water's edge and, if the soil, grass, or other vegetation is stirred rapidly or washed briskly with the water, the Hydrophilids will soon be released and come to the surface. They can then be easily gathered by the hand or, if small enough, by the forefinger. They do not become submerged immediately as do the

Dytiscidæ but swim about on the surface until they regain shore or find some plant to aid them in descending. An examination of the banks adjacent to the collecting grounds at the time of transformation will offer good collecting because often the larval skin, pupal skin, and adult may be procured in the pupal cell at one time. Some of the species are attracted by arc lights during warm nights and, in fact, it is there that *Hydrous* is most frequently obtained.

METHODS OF REARING

The isolation, according to species, of adults, which readily lay eggs in captivity, proved the best method of acquainting oneself with the immature stages. Newly hatched larvæ are thus easily obtained. The most advisable temporary aquarium for such work seems to be a small stender dish. A small stone, half submerged in the water and draped with *Cladophora* gave excellent conditions for egg laying, especially for the smaller beetles which, as a rule, lay their eggs in moist places and not directly in the water.

For larvæ, larger containers produce better results. Moreover, they should be arranged as aquaria-terraria, for many of the adults and larvæ spend most of their time on shore. In preparing this, it is best to get some mud from the bottom or edge of a pool and, after placing it in the container to the depth of about an inch, slope it up gradually so that it forms a miniature bank. The bank end should be normally high enough so as to be a little dry on the surface. *Cladophora* and moneywort make the best plant materials because of their cleanness and lasting qualities. As a rule, the container should be filled so that the bank is covered and then placed in the sun. In a few days, the time depending on the conditions in the pool where the mud was obtained, numerous entomostracans destined to be food for the future larvæ will be present. The vegetation is then added.

The larvæ, when fully grown, seem restless and try to crawl out. If the time for transforming has arrived, they rapidly burrow down and form their pupal cells. Some, however, pupate on the surface of the terrarium, evidently not liking the conditions below. Slightly moist earth seems to be the most natural substance for the terrarium and an inch or so depth will suffice. If not too deep, they will often make their cell next to the glass container, where it is favorable for observation.

II.—LIFE HISTORY AND BIOLOGY

GENERAL SURVEY

Without doubt, the water-scavengers are the most abundant of our water beetles. In this respect they are approached only by the Dytiscidæ which are better adapted to aquatic life. The smaller members of this group are very numerous, and yet are often overlooked.

Their most common habitat is within the confines of some little pool which, as the seasons progress, becomes filled with algæ and other aquatic vegetation. Nevertheless, all the species may be taken in rapidly flowing streams but usually near the bank in débris, moss, etc., or in protected bays, where the water flows the slowest. One isolated record shows the capture of *Cymbiodyta fimbriata* beneath some falls in a bed of moss. The genera which are best adapted for living at some depth and under harsher conditions than the others are *Hydrous*, *Tropisternus* and *Berosus*.

The adult is chiefly herbivorous. It feeds mostly on the lower plant forms, such as algæ, but does not seem to be restricted to this diet. Decaying vegetation is its most popular food and it feeds readily on dead animal tissue (earthworms, larvæ, etc.).

It is an air breather, though much of its time is spent below the water. To obtain air¹ the beetle comes to the surface and extends its pubescent antennæ above water. They are then folded under the head and the air which has gathered on the antennæ is passed on to the hairs of the prothorax. Inspiration takes place by means of the pro-meso-thoracic spiracles only. The air passes through the tracheæ and, as fast as used, is expelled through the other seven pairs of spiracles. It then spreads over the ventral side of the abdomen, where it is held as a film by the hydroscopic hairs. Thus the characteristic air film is formed. When a fresh supply is needed, the used air is passed along the prothorax to the antennæ again and the process repeated. Continual contraction and expansion of the body accompanies this breathing process.

Most of the Hydrophilidæ hibernate as imagines. It would be hard to tell where all of them spend their winter but a number of the species have been found in the bank a few feet from the water. They do not burrow down very deeply but remain near the surface, apparently in readiness to enter the water during any warm spell. An examination of the beetles which were taken from the bank or in early spring often

¹Brocher in his excellent paper (1913) carefully explains the respiration of *Hydrophilus*.

showed their bodies to be covered with many mites. Species of *Podophrya* and of *Epistylus* were also quite frequently observed upon them. Their lack of activity evidently allowed these harmless epizoans to gather on them; after a few days in the aquarium, they were lost.

The principal egg-laying months are May and August, although the egg-cases of some species may be found during the entire summer. The eggs, usually placed in "cocoon" (better called egg-cases) of silken structure, hatch out in about seven days. Many eggs are laid by a single individual, thus making up part of the enormous mortality which occurs among the young larvæ.

The silken material which protects the eggs is secreted by the female from glands located in the caudal end of the body. It is applied by the two spinnerets in a manner very much resembling the way a paint brush is used. A continuous flow of silk is laid down at each turn. According to Miger, there are in *Hydrous* three secretions, each of which has a different use. The first for loose spinning is used for covering the individual egg; the second for constructing the egg-case; and the third to form the mast at its tip. The function of this mast is a problem, although many suggest that it aerates the case. Several genera place their cases or single eggs below water, so that this supposition does not appear entirely plausible.

The larvæ, when first appearing, are whitish in color, except for the reddish pigment of the ocular areas, but soon the chitinized portions of the body darken. The first duty of the aquatic larvæ is evidently to get what is called an "air drink." They lift their heads above water and, with the aid of a pharyngeal pump, draw air into their alimentary canal. Air is also taken into the tracheæ through the stigmatic atrium which rests upon the surface film. By thus supplying their bodies with air the larvæ become buoyant. Otherwise they would be heavier than water and soon sink, dying because of lack of oxygen.

The larvæ are carnivorous and cannibalistic as well, the different genera varying in their greed. The young larvæ feed upon small organisms (entomostracans,¹ *Tubifex*, leeches, etc.) and increase the size of their prey as they themselves increase in size.

The full-grown larva feeds readily on pollywogs, annelids, fish, and, in fact, almost anything that it can overcome or that is fed to it. It lies in wait for its prey with its jaws extended widely and, as a rule, is half in the water and half out, the caudal end being out. When it begins

¹*Halophorus* was observed feeding on *Simocephalus*, *Cypris*, *Cypridopsis*, *Cyclops*, and *Canthocampus*.

eating, the larva lifts its head out of the water and manipulates its food by means of the mouth-parts. The labium and maxillæ are used as guides and to hold the prey while the mandibles macerate it. The legs play no part in the handling of the food. Predigestion occurs and the dissolved food is then drawn into the mouth by the suction of the pharynx.¹ There is neither lock to the mouth nor tubes in the mandibles such as are found in the dytiscid larva. This method of feeding refers only to the aquatic larvæ of the family and to *Helophorus*. I have not observed the feeding of the other, terrestrial forms. According to d'Orchymont, however, predigestion apparently does not take place in them.

There are usually two molts occurring during the larval period, which lasts one or two months. *Hydrobius*² evidently proves an exception to the rule, as its larvæ are found nearly full-grown in the early spring and even then do not transform immediately. The typically aquatic larva grows very rapidly and the first two instars take only about a fortnight. Most of its life is, therefore, spent in the third or last instar.

When ready to pupate, the larvæ leave the water and burrow in moist earth, often under stones or sticks, where they mold a cell slightly larger than the pupa to be formed. In the prescribed time (3-7 days) the pupal skin is ruptured and the adult emerges soon after but usually remains in the cell until fully colored.

EXPLANATION OF TERMS USED

In order that the terms that are used in the technical descriptions may be understood by the reader, a brief explanation of them is given here and illustrations of typical structures are shown in Plate I. No work has yet appeared in this country which deals with the difficult structures of a campodeiform larva such as we find in this family. Hopkins' paper on *Dendroctonus* has proved very useful, but the structures of that type of larva have not been compared with those of the hydrophilid type. I have, therefore, used, for the most part, the terms employed by European writers. D'Orchymont does not discuss the various terminologies, except in regard to the stigmatic atrium. However, his labeled figures of the mouth-parts and his numerous notes aid materially in giving one a clear understanding of his interpretation of

¹Method described by Balfour-Browne, 1910.

²Miall reports hibernation in larvæ of *H. fuscipes* and the author has observed it in *H. globosus*.

the various structures. Dr. Böving, who has studied the attachment of muscles in larvæ, has kindly offered valuable suggestions as to the homologies of the abdominal folds.

The fully developed and typical hydrophilid egg-case consists of the egg-case proper, containing the eggs; a cap covering the entrance to the latter and a projection continuous with the cap, which may be either a horny mast, tube, or filament. In giving the measurements of the case, the cap has always been considered as one end of the case.

The head of the larva may be inclined, horizontal, or elevated, with respect to the axis of the body, depending upon the shortening or lengthening of its upper or lower side. The epicranial suture, which may be present or absent, is formed by the union of the frontal sutures along the median line. The gula is the sclerite to which the submentum is attached. The epistoma is the sclerite just behind the clypeus and its lateral expansions attain the front margin of the head just lateral to the labro-clypeus. Schiödte called their angular projection the frontal angle. The upper surface of the mouth region on the under side of the labrum is the epipharynx; and, on the under surface, continuous with the mentum, is the hypopharynx. Ocular area is the term used for each of the eye spots behind the antennæ because ocellus is misleading and must be restricted to the adult. The antennal appendage is a finger-like lobe borne by the second segment of the antenna, and there may be two of these appendages. The *lacina mobilis mandibuli* is a flat unjointed lobe which the posterior piece of the mandible bears; it is toothed apically. The molar surface of the mandible is the grinding inner surface near its base. The parts of the labium and maxillæ may be seen in Plate I, figs. 1 and 5. Palpifer is restricted to the palpus-bearing segment of the maxilla, while palpiger is applied to that segment of the labium. "Articulating piece of maxilla" refers to the area between the cardo and the labium upon which the maxilla articulates.

A segment of the larva consists of a tergum, two pleura, and a sternum. The folds of the abdomen are very confusing and need further study. I have considered the hypothetical types of the abdominal tergum as possessing four transverse areas, namely, the præscutum, two scuta and a scutellum. The præscutal area is flat, while the other areas are represented by transverse folds. Between adjacent segments of the abdomen, there is a prominent region which is called the "intersegmental membrane." This may possibly be the postscutellum, but it has not been considered as such in this paper. The number of folds in this area is two at the most

The spiracular area, which bears the spiracle, is just lateral to the tergum.

The pleural region is composed of the hypopleurite and the epipleurite, the latter above the former. They are usually fairly distinct and bear lobes. The sternal region usually consists of the same number of folds as the tergal region but is much more complex. As in the latter, there are corresponding folds known as the præsternum, sterna (two folds) and sternellum.

The stigmatic atrium, or caudal breathing apparatus, offers opportunity for controversy as to the segments which compose it, but I have considered it as formed by the modified eighth and ninth segments. The procercus is the process of the eighth pleurite; the mesocercus, or true cercus, is always an appendage of the ninth segment; the acrocercus is an appendage of the lateral lobe of the ninth segment and arises from its ventral side; and the prostyle ("flotteurs" of Portier), which precedes the anus, is an appendage of the tenth segment. The motory stylus is a fleshy process of the pupa, resembling a seta. It may or may not bear a terminal seta and is usually annulate. The pterotheca is the pupal covering of the adult wing.

GENERAL CHARACTERS OF THE FAMILY (IMMATURE STAGES)

The eggs are whitish (brownish in *Hydroscapha*), oval in shape, and with a small projection at the anterior end. The eggs, varying in number from one to one hundred and forty odd, are usually enclosed in a silken case¹ but, in the more primitive forms (*Ochthebius*, *Limnebius*, and *Hydroscapha*), the eggs are deposited singly, without any covering or with one of loosely applied silk. *Cymbiodyta* and *Paracymus* lay their eggs in masses but cover them only sparsely with silk. The cases are either free floating (*Hydrous*, *Hydrophilus*); attached to water plants or débris at the surface of the water (*Tropisternus*, *Philydrus*, *Hydrobius*, *Laccobius*, *Ancæna*); below water (*Berosus*); embedded in mud, moss, etc. (*Hydrobius*, *Helophorus*); carried on the under side of the body (*Spercheus*, *Epimetopus*, *Helochaeres*, *Chætarthria* ?); or placed in dung or damp earth. The egg-masses of *Cymbiodyta* and *Paracymus* and the single eggs of the more primitive species are deposited under fallen leaves, vegetation or stones near the edge of the water.

¹Stein, 1847, who found silk glands in many genera, supposed that all eggs were covered with silk but the degree of covering varies greatly.

The larva is campodeiform; its head inclined (more primitive genera), elevated (more specialized genera), or nearly horizontal (*Helophorus*, *Hydrochous*); ocular areas in groups of five or six, distant or aggregated, reddish, round or oval, convex or flattened; antennæ three-segmented, rarely four-segmented (full-grown larva of *Hydrous triangularis*); epicranial suture present or absent; points of insertion of antennæ situated nearer or farther from the externo-frontal angles than those of the mandibles; labrum and clypeus well developed and distinct (more primitive genera) or reduced and fused (more specialized genera); mandibles with *lacinia mobilis* or sharply pointed and with inner teeth; maxilla palpiform or with stipes possessing a well-developed inner lobe; maxillary palpi three-segmented; labial palpi two-segmented; ligula present or absent; gula well developed and attaining the occipital opening or reduced and not attaining the occipital opening; labium and maxillæ inserted in a furrow on the under side of the head (more primitive genera) or not inserted in a furrow (more specialized genera); legs segmented and with claw-like tarsi, without tarsi (*Sphaeridium*), or legs entirely absent (*Cercyon*).

Abdomen with nine well-developed segments and a reduced tenth or eight well-developed segments and reduced ninth and tenth. The body is usually slightly chitinized. The types of breathing overlap but there is a marked tendency in each genus towards one of three types: holopneustic, apneustic, or metapneustic. The spiracles (one pair of mesothoracic and eight pairs of abdominal) may be well developed before spiracles (*Helophorus*), annuliform spiracles (*Ochthebius*, *Limnebius*, *Hydræna*), apparently absent (*Hydroscapa*), or poorly developed before spiracles (the remaining genera). Cerci absent (*Hydroscapa*) or present as three-segmented or two-segmented appendages; reduced in the higher forms.

The pupa¹ is usually white in color except the eyes, which are reddish at first but change to nearly black before emergence. However, *Tropisternus lateralis* and *Hydrophilus obtusatus* are greenish. The anterior and posterior ends of the body are incurved and are not visible from the dorsal side. The integument is smooth, except that it is sparsely covered with styli. The supraorbital setæ are usually present but there is only one in *Hydrous triangularis* and none in *Tropisternus glaber*. The pronotal styli vary in number and size. There are only sixteen in

¹The pupa of the most primitive forms has not been described.

Helophorus and thirty-two in *Hydrophilus*. The number seems to be constant in the Hydrobiinæ as all specimens examined had twenty-four styli. Both the meso- and metathorax have a dorsal transverse row of two setæ. The wings are folded down over the ventral side of the body and the metathoracic pterothecæ may (terrestrial species) or may not (others) be visible from above. The first to seventh abdominal segments each possess, dorsally, a transverse row of four to six styli. The second to seventh abdominal pleurites each bear a stylus. The cerci are present and well developed.

GENERAL CHARACTERS, LIFE HISTORY, AND BIOLOGY
OF THE FORMS STUDIED

1. **Helophorinæ**

Egg-case proper continuous with a distinctly hollow tube at the cap end. Many eggs enclosed. Larva with the head nearly horizontal, slightly elevated; ocular areas round, convex, and in groups of six, closely aggregated; antennæ with their points of insertion nearer the externo-frontal angles than those of the mandibles; antennal appendages of second segment two in number; epicranial suture absent; labrum and clypeus reduced; mandibles stout, sharply pointed, and with distinct inner teeth; labium and maxilla inserted at the anterior margin of the under side of the head; maxilla palpiform; palpiger slightly dichotomous at the distal end; gula reduced and distant from the occipital opening. Abdomen with nine complete segments, each with tuberular areas, the tenth distinct but reduced; cerci three-segmented. Holopneustic type of breathing with well-developed bifore spiracles.

HELOPHORUS Fabricius

Often taken in company with the common *Ancæna* and *Paracymus*, these three genera are the most abundant in the Cayuga Lake basin. All representatives of this genus may inhabit the same pool but more frequently the different species seem to be segregated. It is difficult to distinguish the various species in the field but, as a rule, *H. lacustris* may be known by its usually larger size. In addition to it, *H. linearis*, *H. viridicollis* (*lineatus*), and *H. granularis*, named in the order of their abundance, are found here. Very little work has been done in this country on the species. They are very close to each other in structure. Distribution is limited, the representatives occurring only in the pale-arctic, nearctic, and Central American regions. European authors have worked extensively on the life histories of *Helophorus* and they are listed in the table (page 5), but in America nothing has been done. However, *H. granularis*, which Schiödte described, is holarctic.

Egg-cases were taken out-doors in May and June. The cases were formed in moss or alga near the bank with only the tubular filament exposed, the egg-case proper being hidden completely. From six to ten eggs were found in each of the cases. During the latter part of May several larvæ were taken, in company with *Ancæna* larvæ, from the under side of a stick at the water's edge. While the larvæ have been observed eating entomostracans and various other animal tissue, it is worth recalling Perris' note that *H. rugosus* was observed in the stalk of *Brassica* preying on a *Psylliodes* larva.

Helophorus lacustris LeConte

Plate II

Two egg-cases were noted deeply embedded in moss at the water-line and only the tubes were visible. The cases proper were covered with sand and mud but the tubular filaments were clean and white. Thirteen larvæ were obtained from these cases and they made their escape through the tubes. A preserved case shows three of the larvæ in the tube at one time, one behind another. Several other cases were obtained in the laboratory, where they were laid in some alga which had been pulled out of the water and placed on the side of the aquarium. A part of the alga was left hanging in the water and this kept the remainder moist.

EGG-CASE¹ somewhat flask-shaped. Egg-case proper nearly round, measuring 1.69 mm. in width; tube, 0.94 mm. wide distally. The whole 4.84 mm. long; the opening is obliquely across the end of the tube and extends 1.076 mm. down the side.

NEWLY HATCHED LARVA.—Length, 2.55 mm.; width, 0.403 mm. Whitish except chitinated portions, which are brownish with head yellowish in part; integument more chitinous than in other larvæ and with only a few scattered setæ.

Head quadrangular, only slightly elevated, dorsal side one-half the ventral in length, posterior margin with a prominent semicircular emargination; fronto-clypeal suture weakly indicated, more prominent towards the middle; frontal sutures converging gradually and joined by a short transverse suture contiguous with the posterior margin of the head; epicranial suture absent; gula polygonal; gular sutures confluent; cervical sclerites evidently not present.

Labro-clypeus triangular (subconical). Lateral expansion of the epistoma prominent, similar, rounded, about even with the anterior margin of the labro-clypeus and each bearing seven, stout, recurved spines; epipharynx spinous.

Ocular areas in groups of six and closely aggregated; roundish; arranged in two rows of three each and all equidistant from each other. The hind row set slightly nearer the median line than the front row.

Antennæ short, slightly exceeding the mandibles; first segment about as long as the second, slightly constricted near the base; second segment widened towards the tip, obliquely truncate, possessing distally in the membrane a pair of two-segmented, lobiform antennal appendages on the outer side in addition to a strong seta and two strong distal setæ on the inner side; terminal segment cylindrical, much narrower than the other segments and provided with several apical setæ.

Mandibles symmetrical, prominent, sharply pointed at their tips and with the inner surface of the anterior piece serrate; two² inner teeth on each mandible about equal in size; a strong medio-lateral spine present; molar areas smooth.

¹The egg-case of *H. aquaticus* figured by Schiödte differs greatly from our generic type and I doubt his accuracy.

²*H. granularis* has only a single inner tooth.

Maxillæ with palpifer not joint-like; stipes fairly large, swollen, not noticeably narrowed towards the apex, only a little longer than the palpifer, its inner surface provided with a row of five stout setæ, another just inside the most distal one and two slender setæ near the externo-distal angle; palpifer fairly large, a little longer than wide, bearing an inner stout lateral seta; a slender seta in the externo-distal angle and a slender cylindrical appendage in the interno-distal angle, exceeding the first segment of the palpus, with sense-cones and a seta at its tip as well as those nears its base; palpus cylindrical, tapering slightly with sense-cones at the distal end; the second segment slightly longer than the other two.

Labium not exceeding the mandibles, but prominent and just attaining the distal end of the palpifer; submentum small; mentum not exceeding the tooth of the labro-clypeus, cylindrical, a little longer than wide, and slightly swollen distally; palpiger equal to the mentum in length, its sides diverging and forked distally; the palpi, borne by the two forks, cylindrical and tapering; the second segment about twice as long as the first and with sense-cones at the tip; ligula absent.

Prothorax with angles obtuse; well indicated, only a little wider than the head, sides parallel; anterior and posterior of pronotum non-chitinated; sagittal line present; prosternum chitinated in front and lateral to the coxæ. Mesothorax and metathorax equal to each other in length but shorter than the prothorax and becoming very slightly narrower than the latter caudally. The nota are entirely chitinated and each bears a transverse row of four prominent setæ. The sagittal line, which continues throughout the eighth abdominal segment, prominent. A pair of bifore spiracles on the mesothorax.

Legs fairly long, slightly longer than the thorax is wide; coxæ transverse, grooved laterally to receive the femora; femora a little longer than the tibiæ; tarsi claw-like, about as long as the latter and with no inner setæ; the anterior coxæ are closer together than the four posterior coxæ, which are about the same distance apart.

Abdomen with nine distinct segments, very slightly narrowed caudally. Anal segment projecting, short and cylindrical; the first seven abdominal tergites similar and resemble the meso- and metanota in the arrangement of the setæ and their chitination. Dorsally a row of four setæ on each segment, each seta emerging from a broad, rough tubercled area, which is chitinated and separated from the others by a longitudinal furrow or suture. Laterally two similar chitinated tubercled areas, the posterior one larger and with a seta (both probably correspond with the epipleurite); hypopleurite similar, one-lobed and with a seta. The sagittal suture very distinct as well as the longitudinal furrows. Ninth segment narrower than the eighth and nearly twice as long with a prominent lateral seta on each side, corresponding to the seta of the lateral tubercled areas just mentioned; only the tergite is chitinated. Arising from the posterior margin are two divergent, three-segmented, cylindrical, tapering cerci. The first segment bears a ventral and dorsal seta, the second a terminal seta just below the origin of the third segment, which has a terminal seta as long as the three segments together. The three segments bear the relation of 16, 12, and 18 to each other in length. Each spiracle¹ is just below and in front of the outer dorsal tubercled area. First eight sternites with a transverse row of four tubercles, each bearing a seta which has a small, chitinous plate at its base, and a small seta each side of the median line near the anterior margin. Three transverse folds are present

¹Compared with the other Hydrophilidae, which possess them, the bifore spiracles are well developed.

ventrally, the first ovo-oblong, the second somewhat rectangular, and the third tripartite with the middle bilobed, each lobe with a seta, the lateral parts triangular and with a seta.

***Helophorus aquaticus* Linnæus**

The identical life history material of this European species used by Schiödte in his work on this genus is located in the collection of the United States National Museum but is in poor condition. An examination of the full-grown larva shows that the sclerites in front of the procoxæ are not so prominent as in the younger larvæ. The abdomen is only slightly more strongly chitinized than in the first stage larva and the intersegmental membranes are present but not prominent. The setæ are lost in the specimen examined but this may be due to its poor condition. The following pupal description may well be incorporated.

PUPA.—Length, 8.5 mm.; width, 2.00 mm. at its thorax. Whitish (specimen browned with age). Head smooth and bears two supraorbital styli on each side. Pronotum smooth, its anterior margin somewhat trilobed and its posterior margin with a large median lobe. The styli¹ are arranged as follows: ten on the lateral and anterior margins, two of which are on the middle lobe; six on the posterior margin, counting the two corner ones; no styli are to be seen in the central area of the pronotum but may have been destroyed. (Schiödte's figure gives none.) Mesonotum and metanotum with a transverse row of two setæ. Inner spur of metatibia fairly prominent. All tarsi probably ending in a spine but not very clear and tibiæ not noticeably spinous on the outer side. Metathoracic pterothecæ conspicuous from above. First to seventh abdominal tergites with a transverse row of four styli. Second to seventh pleurites each with a stylus, all arising from small conical tubercles; eighth tergite somewhat semicircular, the rounded posterior border bearing two styli; one lateral stylus noted on each side below the eighth tergite; ninth segment with a pair of short, conical, fleshy cerci about the same length as the ninth tergite. They diverge only slightly and their sharp tips point inwardly.

2. *Limnebiinæ*

Eggs laid singly with a slight covering of loosely applied silk. Larva with head inclined; antennæ with points of insertion situated nearer the externo-frontal angles than those of the mandibles; epicranial suture present; ocular areas round, convex and in groups of five, not closely aggregated; labrum and clypeus both well developed; mandibles each with a *lacinia mobilis*; maxilla primitive with an inner lobe; labium with short palpi; fleshy ligula present; labium and maxillæ inserted in a furrow on the under side of the head; gula well developed and attaining the occipital opening. Nine complete abdominal segments each with a ventral and dorsal plate, and a distinct but reduced tenth or anal segment. Cerci two-segmented. Holopneustic type with annuliform spiracles.

¹The basal part of the stylus is short and the terminal seta long.

LIMNEBIUS Leach

D'Orchymont gave the first description of the larva of *Limnebius*. The eggs and pupa have not been described.

Limnebius discolor Casey

Three specimens were taken the latter part of June near the bank of an alga-filled pool. The species is rare and has not been previously reported from Cayuga Lake basin. It is difficult to recognize in the field on account of its small size, but closer examination shows clearly its resemblance to the Hydrobiinæ type, with which it was formerly classed.

The eggs were laid on July 1 by captured specimens and one egg hatched on July 8. As this was the only larva obtained, it is considered inadvisable to give a description of it. However, the larva very closely resembles *L. truncatellus*, which d'Orchymont carefully described.

3. Hydræninæ

Eggs laid singly. In *Ochthebius* with or without a slight covering of loosely applied silk but in *Hydræna* covered with a blanket of closely spun silk.

Larva as with *Limnebiinæ*.

OCHTHEBIUS Leach

Ochthebius offers many interesting structures. *O. tuberculatus* is particularly unique and cannot be mistaken for any of the other species. Besides *O. tuberculatus*, *O. holmbergi* and several other undetermined members occur in the Cayuga Lake basin.

All of them are, in general, quite rare. However, when once located, many are usually collected in a very small area and one collecting ground kept me well supplied from late April until winter set in. The soil in this spot was especially sandy. Upon washing the sand with water and pulling up and washing the roots of the vegetation which grew there, many specimens were soon observed floating on the surface of the water or clinging to floating débris.

Haliday, 1855-6, was the first to figure a larva of this genus, namely, *O. punctatus*. The latest and best study is that of d'Orchymont. He worked out in detail the larva of *O. lejolisi*, already described by Mulsant and Rey, 1861, and worked over by Fauvel, 1865. D'Orchymont also dealt with *steinbuhleri* and *impressus*. Rey, 1887, added *O. quadricollis* to the list of known larvæ.

Single eggs were deposited on the stones or algæ in an aquarium, out of water but in moist places. They were either entirely naked or, at times, covered rather uniformly with loosely applied silk. The silk was more compact, however, than in the scattered silk of the *Cymbiodyta* egg-masses but not as closely applied as in the complete egg-cases. The eggs were most frequent during May but some were laid the first part of July. From seven to ten days were required for incubation.

The larvæ are very different from those of the Hydrobiinæ and even from those of the Helophorinæ but are closely allied to the Limnebiinæ. On land, they move very rapidly and almost seem to run. They are very clumsy in water and doubtless spend their life on land but in moist situations. According to d'Orchymont, p. 190, the life of the larva probably lasts only two or three months. Adults of *O. impressus*, which he captured the first of August in order to restock his aquaria, were not fully colored, thereby indicating their recent emergence.

***Ochthebius tuberculatus* LeConte (*foveicollis* LeConte)**

Plate III

At times the collecting of this species proved so easy that they could be picked up almost indefinitely, the collector stopping only to wash them out. In the middle of September 1916 many were found in gravelly places which were practically devoid of vegetation. One can easily recognize them in the water because of their somewhat heart-shaped abdomen, which often sinks lower than the rest of the body.

EGG.—Length, 0.538 mm.; width, 0.215 mm. Naked or covered with loosely applied silk which is placed regularly so that the whole is uniform in shape.

NEWLY HATCHED LARVA.—Length, 1.345 mm.; width, 0.242 mm. Whitish, except the chitinized portions which soon become brown. Integument with many inconspicuous setulæ as well as regularly arranged setæ, which are fairly long, rigid, and brownish.

Head well rounded, globular; fronto-clypeal suture fairly well indicated; frontal sutures converging, uniting behind the middle of the head to form the epicranial suture, the whole presenting a Y-shaped appearance; frons somewhat triangular.

Gula fairly small, constricted laterally, the anterior and posterior angles produced into arms; cervical sclerites, if present, not noticeable. Epistoma apparently marked off from the frons by an irregular group of minute tubercles.

Clypeus fairly distinct, transverse, slightly arched, wider than the labrum and with a transverse row of six setæ, the median two widely separated but the others equidistant, near the anterior margin.

Labrum somewhat semicircular with four lateral setæ on each side, the anterior one bifurcate, short, and blunt; a stout seta in front of the latter; two, small, adjacent tubercles just inside the anterior margin and two others in a horizontal row

through middle but widely separated; two setæ just posterior and outside the former tubercles and two others posterior but inside the latter tubercles, both in a horizontal row. The lateral expansions of the epistoma not prominent. Epipharynx apparently not spinous.

Ocular areas round, five on each side, not aggregated; the first and second not seen from above, fairly close together and placed one back of the other just behind the insertion of the mandible at the side; the third and fourth about the same distance apart as the first two and located just posterior to the insertion of the antenna, the fourth more dorsal and posterior; the fifth widely separated from the fourth, more lateral and posterior.

Antennæ three-segmented,¹ fairly long, exceeding the mandibles; first segment more than twice as wide as long and less than one-third the second segment in length; latter about the same width, slightly constricted in the middle and with an outer swelling just proximal to the middle, bearing a small, blunt spine; distal end with four long setæ; third segment slightly constricted and distally with several prominent setæ.

Mandibles approximately symmetrical with broad bases, their tips with several finger-like processes, the arrangement on two mandibles differing somewhat; *lacinia mobilis* present, pectinate distally; molar area with numerous spinules and two inner teeth in front of it.

Maxillæ with palpifer joint-like and seeming to form the first segment of the palpus; a large internal lobe present, which clasps the stipes on the ventral side and shows a tendency to be divided distally into two lobes; the outer lobe tapers to a sharp point while the inner lobe is shorter, blunter, and fringed with a row of stout setæ distally as well as with several slender setæ nearer its base; cardo noticeable and as broad as the stipes at its union; stipes wider and longer than the palpifer and with two lateral setæ; palpifer about as wide as long; palpus tapering; second segment slender and only slightly longer than the first; terminal segment very small and somewhat flask-shaped.

Labium with palpi barely exceeding the labrum, short; submentum, reduced, transverse, indistinct; mentum broad but longer than wide, slightly constricted; palpiger transverse, slightly forked; palpus short, two-segmented, articulating membranes well developed; second segment narrower, shorter than the first, its margin flared distally and with apical setæ and papillæ; ligula present, barely exceeding the first segment of the palpus, rounded and furnished with papillæ (very similar to *Limnebius*).

Prothorax with sides and angles rounded, of the same width as the head. Proscutum well developed and entirely chitinized, sagittal line present; anterior and posterior margins with a transverse row of setæ; a median transverse row of setæ and several lateral setæ.

Mesothorax a little shorter than the latter, slightly narrowed in front. Mesoscutum well developed and entirely chitinized, less conspicuously in front; sagittal line present; a transverse row of setæ just in front of the middle and at the posterior margin; several lateral setæ. Metathorax the same. Sterna not noticeably chitinized.

Legs fairly long, about as long as the thorax is wide; coxæ transverse with a dorsal groove; femora about the same length as the tibiæ but a little stouter; tarsi slightly more than one-third the latter, claw-like and with no inner setæ.

¹Articulating membrane at base very prominent but non-chitinized.

Abdomen with ten distinct segments and narrowed caudally. The first eight tergites similar and each covered by a dorsal plate, the posterior angles and margin of which are rounded; a transverse row of setæ at the posterior margin and a fairly prominent seta at each side. Eight pairs of small round spiracles present and each situated in the spiracular area just inside and anterior of the lateral setæ. Pleural groove distinct. Each segment with a ventral plate less chitinized towards the anterior and with setæ arranged as on the dorsal plate. Ninth segment similar to the preceding ones, except that it is slightly longer and the irregular row of setæ are absent at the posterior margin, inside the insertion of the cerci. A pair of two-segmented, divergent cerci arise from the posterior margin of the ninth tergite, their points of insertion almost contiguous. First segment of cercus, longer than the anal or tenth segment, chitinized, constricted slightly in the middle and with several long distal setæ besides other shorter ones; second segment slender but not tapering; less than one-half the first segment in length and bearing a single, long, terminal seta.

Anal segment cylindrical, longer than wide, banded with chitin, the tip membranous, a row of short setæ around the caudal border of the band and a terminal pair of stout, recurved hooks directed downward.

HYDRÆNA Kugel

Only one species, *H. pennsylvanica*, is found in the vicinity of Cayuga Lake. One cannot fail to recognize the members of this genus because of their long, slender maxillary palpi and almost invariably hexagonal pronotum.

Hydræna pennsylvanica Kieswetter

Plate IV

The life history of this minute water scavenger has never been described. The small, elongate beetles are often overlooked unless one collects especially for them. They are found either in flowing or standing water and occur most frequently where the shore is muddy or gravelly. Specimens were collected throughout the spring and summer at the same special collecting grounds but they proved to be most numerous in April and May. Once located, the same spot will yield specimens for the rest of the season. The stock pool for 1915 was one of the railroad pools, east of the tracks of the Lehigh Valley Railroad, Auburn Division, and south of Fall Creek, where on April 14 over forty were taken by washing out the mud at the shore-line. During late August many of the beetles were observed crawling over stones and pebbles where the water lapped the shore of Cayuga Lake near the mouth of Taughannock Creek. Their most common associates are *Paracymus subcupreus*, *Ochthebius tuberculatus*, *Hydrochous squamifer*, and *Cercyon ocellatus*.

As with *Ochthebius*, only one egg is deposited at a time. Eggs were laid in an aquarium during the middle and latter part of April.¹ They were placed on a leaf which rested on a stone, some in the water and some out but always in a damp situation. Each egg was kept in position by a blanket-like covering of closely applied silk which exceeded the egg on all sides and showed its form. The eggs hatch in six to eight days, emerging through a narrow, longitudinal slit in the upper side of the egg-case. The larvæ are very rapid walkers and closely resemble those of *Ochthebius*, almost seeming to glide over the surface of the stones when stimulated. They are clearly non-aquatic in their movements, becoming quite helpless when below the surface film.

EGG.—Length, 0.591 mm.; width, 0.242 mm. The flare-like margin exceeds the egg itself about 0.09415 mm. all around and is entire, being only slightly irregular.

NEWLY HATCHED LARVA.—Length, 1.29 mm.; width, 0.242 mm. Whitish except chitinized regions which soon become brown; integument with many inconspicuous setulæ as well as regularly arranged setæ which are fairly long, stiff and brownish.

Head strongly rounded, globular; fronto-clypeal suture weakly indicated, except at the sides; frontal sutures, converging, unite behind the middle of the head to form the epicranial suture, the whole presenting a Y-shaped appearance; gula small, constricted laterally, and its posterior angles extend to form long, lateral arms; cervical sclerites, if present, not noticeable.

Clypeus fairly distinct, transverse, slightly arched, wider than the labrum and with a transverse row of six equidistant setæ on the posterior half.

Labrum somewhat semicircular with four setæ on each side, the anterior one prominently branched (almost pectinate) while the third pair are strongly bent inward and tapering; anterior margin slightly emarginate with a short, finger-like appendage on each side, with a seta just behind but a little lateral; four other setæ on the upper side of the labrum; two near the middle and two on the posterior half but more widely separated. The lateral expansions of the epistoma are not prominent.

Epipharynx apparently not spinous.

Ocular areas round, five on each side, not aggregated; the first and second close together and placed one above the other just behind the gena² and below the base of the antenna; the third and fourth closely approximated, widely separated from the latter, and more dorsal; the fifth near the lateral margin of the head and distant from the fifth.

Antennæ fairly long, barely exceeding the mandibles; first segment about as wide as long and two-fifths the second segment in length; latter more slender with two swellings on the inner side, one at the middle, bearing a long seta and one near the distal end bearing a finger-like appendage besides a long seta; two seta just below the externo-frontal angle; third segment slender, longer than the finger-like appendage and more than one-half as long as the second with a seta arising from an inner tubercle near the middle and several terminal setæ mounted on tubercles.

¹Many adults were taken in copulo out of doors at this season.

²The sclerite called the gena may open some question but it evidently corresponds in position to it.

Mandibles approximately symmetrical with broad bases, their tips with several finger-like processes; *lacinia mobilis* broad and toothed distally; two small inner teeth; molar area oval with its surface covered with numerous spinules and four small teeth in front of them.

Maxillæ with palpifer joint-like and seeming to form the first segment of the palpus; a large terminal lobe present, which clasps the stipes on the ventral side and is divided distally into two lobes fringed with setæ; the inner lobe with a row of setæ on its inner margin; stipes slightly wider and longer than the palpifer, which bears four inner setæ; palpus tapering and with the second segment slender and longer than the first; terminal segment very small and somewhat flask-shaped.

Labium with palpi barely exceeding the labrum, short; submentum reduced, transverse; mentum broad, cordiform; palpiger transverse, indistinct; palpus short, covering, distally provided with setæ and expanded with a flare-like margin; articulating membranes well developed; ligula slightly exceeding the first segment of the palpus, bowl-shaped and with large rounded papillæ at its tip.

Prothorax with sides and angles rounded, of the same width as the head. Proscutum well developed and entirely chitinized; sagittal line present; anterior and posterior margins with a transverse row of setæ; a median transverse row of setæ and a prominent lateral seta on each side near the middle. Mesothorax slightly narrower but the same length as the prothorax. Mesoscutum well developed and entirely chitinized; sagittal line present; the posterior margin with a transverse row of setæ, a transverse row on its anterior half and a medio-lateral seta on each side. The metathorax the same except that it is a little narrower. Sterna not noticeably chitinized.

Legs long, about one-half longer than the thorax is wide; coxæ transverse with a slight dorsal groove; femora a little shorter than the tibiæ; tarsi claw-like, more than one-fourth the latter in length, with no inner setæ but each with two inconspicuous outer ones.

Abdomen with ten distinct segments and narrowed caudally. The first eight tergites similar and each covered by a dorsal plate,¹ the anterior margin of which is straight while the posterior is rounded; a transverse row of six setæ at each posterior margin and a prominent lateral seta on each side arising from a small tubercle. Spiracles situated just inside and anterior of the lateral seta. Pleural groove distinct. Each segment with a ventral plate¹ less chitinized anteriorly and possessing a transverse row of six setæ near the posterior margin besides several others just anterior. Ninth segment similar to the preceding ones except that it is slightly longer, four inner dorsal setæ are lost, both lateral setæ are more posterior, and the median pair of ventral setæ at the posterior margin are set a little more anterior. A pair of two-segmented, divergent cerci arise from the posterior margin of the tergite, their points of insertion distant from each other. First segment of cercus tapering, longer than the anal or tenth segment, chitinized, and bearing two dorsal setæ near its base, three setæ about one-third the length of the segment from the distal end,² and a terminal ventral one. Second segment small, slender, cylindrical, only slightly chitinized, its tip flattened, membranous and bearing a terminal seta.

¹The dorsal plate represents the scutum fused with the epimerites while the ventral plate represents the sternites fused with the episternites (d'Orchymont).

²The first segment appears to be subdivided but closer examination disproves it.

Anal segment cylindrical, longer than wide, and banded with chitin, the tip membranous, a transverse row of setæ anterior of the caudal border of the band and a terminal pair of stout, recurved hooks directed downward.

4. *Hydroscaphinæ*

Eggs laid singly without a covering of silk.

Larva with inclined head; antennæ with points of insertion situated nearer the externo-frontal angles than those of the mandibles; epicranial sutures present; ocular areas round, convex and in groups of five more closely aggregated than with the other primitive larvæ; labrum well developed but clypeus¹ not present; mandibles small each with a *lacinia mobilis* and concealed from above by the labrum; maxilla primitive with an inner lobe; labium with short palpi; labium and maxillæ inserted in a furrow on the under side of the head; gula well developed and attaining the occipital opening. Nine complete abdominal segments, and a distinct but reduced tenth segment, the chitinized portion of all ten forming a continuous ring. Tracheal gills present on several segments. Spiracles reduced so that the openings cannot be seen. Cerci absent.

5. *Hydrochoinæ*

Egg-case flat with a single egg enclosed. Larva with head inclined, antennæ with their points of insertion situated nearer the externo-frontal angles than those of the mandibles are; epicranial suture absent; ocular areas oval and in groups of six, closely aggregated; labro-clypeus very much reduced, the epistoma apparently at the anterior margin of the head; mandibles prominent, each with a slender distal piece terminating in a stout seta; and with a *lacinia mobilis*; maxilla palpiform, the inner side of the stipes with a small swelling; palpifer without a rudimentary lobe; labium with short palpi and ligula absent; labium and maxillæ inserted in a furrow on the under side of the head; gula small but attains the occipital opening; eight complete abdominal segments, and each with a dorsal and ventral plate. Ninth and tenth segments reduced. Type of breathing pseudo-metapneustic and the bifore spiracles are poorly developed.

Hydrochous Leach

As with the genus *Helophorus*, we find most of the species very closely related. However, the rare *Hydrochous scabratus*, with its prominently tubercled elytra, is a well-marked species. The most common species is *H. squamifer* but two closely allied and undetermined species (possibly undescribed) are almost as abundant. A few specimens of *H. excavatus* ? have also been recorded. The only genus with which the collector might confuse the adult is *Helophorus* but the former is easily differentiated in the water by the angular form and blackish color, which has a decided tendency to be iridescent. The seven-segmented antennæ and discal foveæ of *Hydrochous* clearly separate it from *Helophorus* with its nine-segmented antennæ and discal sulci.

¹The clypeus may have fused with the labrum.

In gathering the species, one finds them most frequently in company with *Ochthebius*, *Hydræna*, *Helophorus*, *Ancæna* and *Paracymus* but a great deal harder to locate, with the possible exception of the two first named. They seem to cling more tightly to the vegetation at the shoreline with their rather powerful claws. Standing water with gravelly bottoms and little vegetation or muddy pools seem to be their most common habitat. About fifty were taken the latter part of August 1916 in a lagoon west of the Cornell Biological Field Station. The waters at that time of the year are filled with *Ceratophyllum* (hornwort), *Spirodela* (duckweed), and *Elodea*, while cat-tails abound, taking root in the muddy bottom. *Hydrochous* was procured at the water's edge by washing the mud away from the roots of the cat-tails. They came to the surface immediately and, although very slow in action, they would quickly become submerged by grasping the vegetation with their claws unless washed out in deeper water. When their station, which seems to change each year, is once located they may be captured in large numbers but, otherwise, only scattered specimens are usually taken. A single specimen of *H. scabratus* was procured in Dwyer's Pond by sweeping the submerged *Elodea*. When the imagoes were placed in the aquarium they immediately sought the under sides of some stones, below the water, but when it was placed in the sun they soon came up, seeking the sunny side. A few days later they were observed eating holes in decaying leaves of moneywort and *Marsilea*, leaving only the tough veins.

The life history has not been described and it has proven to be of particular value in explaining the phylogeny of the family. Although the larva has a well-developed stigmatic atrium, yet its head and mouth-parts are quite primitive.

The laying season seems to be confined to the beginning of summer weather, about the latter part of May and the first of June. From the fifty imagoes taken the latter part of August, not a single egg-case was obtained. A number of the beetles were taken *in copulo* on May 10 but no cases appeared until about May 23. A single egg was deposited at a time and placed between two layers of closely applied silk. The cases were fastened down to the algæ or rocks in the aquarium, either above or below water, and held firmly by the flap and stanchions. One case of *Hydrochous* sp.? was particularly well supplied with little stanchions. The egg-case of this genus is apparently one step forward from the egg-case of *Hydræna* in specialization.

The larvæ appeared through a rupture in the silk in about seven to eight days. They were quite at home in the water and the manner in

which the lobes and cerci, around the terminal spiracles, spread out over the surface of the water showed clearly its advanced development. They are much less active out of water than the Hydræninæ but nevertheless move rapid.

Hydrochous squamifer LeConte

Plate V

EGG-CASE.—Length of egg, 0.5 mm.; width, 0.2 mm. The case is irregular in outline and varies in size but the egg is always placed towards one end of the case, the two layers of silk meeting to form a flap at the other end.

NEWLY HATCHED LARVA.—Length, 1.8–1.9 mm.; width at the thorax, 0.21–0.24 mm. Whitish except chitinized regions which soon darken; integument with many inconspicuous setulæ. Body somewhat cylindrical.

Head strongly rounded, shorter than wide, nearly horizontal; fronto-clypeal suture not visible; frontal sutures converging as far back as the middle of the head but then slightly diverging and not uniting to form the epicranial suture, the frons therefore concave at the sides; gula small, its posterior angles extended to form long lateral arms; cervical sclerites, if present, not noticeable.

Labro-clypeus very much reduced, the epistoma apparently at the anterior margin of the head, nearly straight in front, no toothed lobe present but with a transverse row of eight setæ at the anterior margin arranged in two groups of four equidistant from the median line; area immediately behind the latter bearing numerous setæ mounted on minute tubercles. Lateral expansions of the epistoma not prominent, rounded, and similar. Epipharynx with setæ on small tubercles; ocular areas in groups of six, oval, closely aggregated, arranged somewhat in a circle (the third and fourth slightly distant) with their longitudinal axes emanating from the center.

Antennæ fairly short, reaching only to the middle of the palpifer; first segment stout, slightly concave on the inside and slightly convex on the outside, about one-third longer than wide; second segment less than one-third the latter in length, narrower, a little longer than wide and bearing distally a finger-like antennal appendage in addition to the third segment; the latter not quite as long as the second segment and about as long as the appendage but a little wider and bearing terminal sense-cones. The intersegmental membranes separating the segments are well developed and allow the last two segments to be telescoped.

Mandibles symmetrical, the anterior pieces fairly slender, only slightly tapering, the tips membranous and each bearing a short recurved seta; *lacinia mobilis* slender and bifid at the tip; a single, sharply pointed inner tooth just in front of the molar area; latter setiferous.

Maxillæ with palpifer joint-like, stipes large, sides parallel, the inside with a prominent swelling surmounted by a group of setæ; palpifer shorter but equal in width, about as long as wide, swollen, three prominent inner setæ in addition to many small setæ mounted on minute tubercles, which cover the inside of the stipes as well; palpus tapering slightly, the second segment longer than the first but shorter than the thimble-like terminal segment which possesses apical sense-cones.

Labium barely exceeding the stipes of the maxilla, union of submentum and mentum not clear but submentum probably small while mentum is longer and cordiform; palpiger about as long as wide, cylindrical; palpus short; the first segment about one-half the second, which has small distal setæ that are mounted on minute tubercles. Ligula absent.

Prothorax with sides rounded, of the same width as the head; entirely chitinized; sagittal line present throughout the thorax. Meso- and metathorax similar, of the same width but a little shorter than the prothorax.

Legs not quite as long as the thorax is wide and robust; coxæ oval, transverse and with a dorsal groove; femora, tibiæ, and tarsi all about the same length; tarsi well developed, basal part long, claw-like and bearing two inner setæ.

Abdomen with eight distinct segments, all of the same width, ninth and tenth rudimentary. The first seven tergites similar and intersegmental membrane not well defined. Each segment covered with a dorsal plate, the anterior margin of which is straight while the posterior is rounded; no prominent setæ present but a lateral inconspicuous seta. Bifore spiracles mounted on small tubercles, just inside and anterior to the lateral seta. Pleural groove distinct. Each segment apparently with a ventral plate corresponding in structure with the dorsal plate; eighth segment with sides only slightly rounded out, of the same width as the preceding one. It represents the superior valve of the stigmatic atrium and its caudal border is four-lobed, each lobe bearing a seta.

Procercus, or process of the eighth pleurite, one-segmented with a terminal seta.

Mesocercus (cercus) two-segmented, tapering, the first elongate dome-shaped, the second about the same length but more slender and with a terminal seta and covered with several small tubercles, each with an apical seta.

Ninth tergite divided into three lobes, two lateral and one median; median lobe¹ small and a little longer than wide with its caudal margin nearly straight and bearing a short but prominent seta at each caudo-lateral angle; outer or lateral lobes large, rounded and with a terminal seta; acrocercus below and its distal end shows between the lateral lobe and the median lobe just mentioned.

6. *Sphercheinæ*²

Egg-case carried by the hind legs and held on the under side of the body. Larva with head slightly inclined; ocular areas round and in groups of five, not closely aggregated; antennæ with points of insertion nearer the externo-frontal angles than those of the mandibles; epicranial suture very short, almost absent; labro-clypeus very much reduced, the epistoma apparently limiting the front margin of the head; mandibles stout, sharply pointed, furrowed internally and with inner teeth; maxilla palpiform but with palpifer bearing an inner lobe or lacinia; labium with palpi and ligula short; labium and maxillæ inserted in a furrow on the under side³ of the head; gula well developed and attaining the occipital opening. Eight complete abdominal segments, the ninth and tenth reduced. The type of breathing is pseudo-metapneustic and with poorly developed bifore spiracles. Seven pairs of short conical gills on the first seven segments. Cerci and prostyles present but reduced.

¹This median lobe seems to articulate at its base and may be the remains of the tenth segment of the lower Hydrophilidæ.

²This subfamily is not represented in this country but is incorporated on account of its unique specialization.

7. **Hydrophilinae**

Egg-cases characterized by their horny mast and comparatively larger size. Larva with elevated head; antennæ with points of insertion farther from the externo-frontal angles than those of the mandibles; second segment without an antennal appendage; epicranial suture absent or very short; ocular area flat, elongate and closely aggregated although distinctly separated; both labrum and clypeus almost entirely reduced, the front margin nearly straight and with only a few small teeth. Mandibles prominent, sharply pointed, furrowed internally and with inner teeth; maxilla palpiform, slender, the stipes longer than the palpifer and palpus together, palpiger with an inner rudimentary lobe; labium with palpus longer than in the primitive genera, the second segment distinctly longer than the first; ligula present, labium and maxillæ inserted at the anterior margin of the under side of the head; gula reduced and not attaining the occipital opening. Legs provided with fringe of setæ. Eight complete, non-chitinized abdominal segments; ninth and tenth reduced. Type of breathing pseudo-metapneustic and with poorly developed bifore spiracles. Tracheal gills, if present, not well developed. Cerci reduced but two-segmented. Prostyles present or absent.

HYDROPHILUS Leach

There are fewer species in this genus than there are in *Hydrous*, but the members of *Hydrophilus* are more equally distributed over the world. One of the four American representatives, *H. obtusatus*, occurs at Ithaca.

The well-known European species, *H. caraboides*, was one of Linnæus' species and Roesel in 1749 knew some of its larval instars besides the pupa. Lyonet was the first to describe the egg-case and Schiödte later gave the entire life history. The egg-case and young larva of *H. obtusatus* were figured by Bowditch in 1884. He gave a very interesting account of its biology but did not observe the pupa. The full-grown larva and pupa were later described by Wickham but the figures are of little value and the descriptions meagre. Although it varies in size, it is our second largest hydrophilid and is intermediate, in this respect, between *Tropisternus* and *Hydrous*. The beetle is very clumsy and in no way approaches the two other genera of this subfamily in aquatic adaptation. It is most frequently found in leaf-filled pools, mud holes, at the water's edge under débris or clumps of grass, or in pools overgrown with vegetation. Several adults are often taken together in such situations, but only isolated specimens are usually recorded.

Hydrophilus obtusatus Say

Plate I, Figures 1, 2, and 6; Plate VI

The egg-cases of *H. obtusatus* appear in late May and early June but are not often reported. The fact that they are usually covered with a

dead leaf makes it more difficult to see them. They float freely and are the most picturesque of all the egg-cases. A case was formed indoors on April 22 and, as there were no leaves present in the aquarium, it was placed in a mass of floating algæ. No definite air chamber such as is found in *Hydrous* is present. The eggs, about forty in number, are laid in a vertical position at the bottom of the case. Just behind the cap is a mass of loosely spun silk. The cap end is never covered by the leaf but the larvæ do not always emerge underneath it, as seems to be the rule in *Hydrous*. More often the escape is made at the other end.

The young larvæ fed readily on *Cyclops*, *Cypridopsis*, etc., and made several attempts to catch small tadpoles. Freshly killed tadpoles were placed within their reach but they evidently did not care for the dead food. According to Bowditch, they become full grown in about thirty days and spend the remainder of the summer and winter as pupæ, emerging early in the spring. Such an extraordinary length in the pupal stage may be true but it does not sound plausible nor is it always the case.

In July a mature larva was captured floating in the middle of a lagoon near the Biological Field Station. It was placed in a terrarium and on July 21 started burrowing down. After several attempts to form a suitable cell below the surface, it finally pupated above ground July 28. The process of transformation took less than an hour and a beautiful sea-green pupa resulted. Five days later the adult emerged. At the time of emergence the beetle was piceous above but its under side was light brownish in color.

EGG-CASE.—Whitish except brownish mast and plate at its base. Case without the leaf 9.2 mm.—18 mm. long, 9.8 mm.—11 mm. wide, and 7.8 mm.—9 mm. high. The horn-like mast, arising vertically from the top of the largest or cap end of the case, is from 7 mm.—11.8 mm. in length. It is enlarged at the base into a roundish plate about 4.—4.5 mm. high. The top of the mast is often bent forward and away from the case.

NEWLY HATCHED LARVA.—Length, 6.5–7 mm.; width at the thorax, 1.25 mm. Light brownish in color. Integument entirely pilose.

Head broadly ovate, constricted behind, elevated; fronto-clypeal suture well indicated at the sides; frontal sutures gradually converging but not uniting until they attain the caudal margin of the head; frons raised in the middle; gula reduced, arched, semicircular, and with the gular sutures prominent and confluent. Cervical sclerites present.

Labro-clypeus nearly symmetrical, reduced, with very small inconspicuous teeth at the anterior margin and a row of five small setæ equidistant from each other. Lateral expansions of epistoma similar and broadly rounded, overlapping the bases small short setæ along their margins.

Ocular areas in groups of six arranged in two parallel rows, the first three nearly vertically, while the posterior three are horizontally placed. The sixth area or outer one of the posterior row distant from the fifth. Articulating maxillary piece fairly well developed.

Antennæ slender, extending forward about as far as the tips of the mandibles; first segment much longer than the second and third together, slightly constricted near the base, a little crooked and with a few short conical spines on its inner surface; second segment bent inwardly a little, slightly longer than the terminal segment and with a disto-medial seta; latter segment more slender and possessing a few distal setæ.

Mandibles symmetrical,¹ prominent, elongate, sharply pointed at their tips and with their inner surfaces grooved; each mandible with two inner teeth, the proximal tooth smaller than the distal and slightly bifid; distal tooth furrowed on its inner surface, and the furrow is continuous with a furrow surrounding the proximal tooth.

Maxillæ slender and with joint-like palpifer; stipes swollen near its base, slightly bowed, longer than the palpifer and palpus together and its inner surface with a row of five setæ, the basal four fairly stout; palpifer with a small chitinous appendage bearing a terminal seta at its disto-medial angle; about twice the length of the 1st palpal segment but only very slightly wider; palpal segments all about the same width and bearing the relation of 7, 13, and 20; terminal segment with a single distal sense-cone.

Labium prominent, palpus nearly attaining the distal end of the stipes, its first segment short, the second the same width but about five times as long and with terminal sense-cones; ligula well developed, more than twice as long as the first palpal segment, cylindrical, only slightly tapering, chitinized except tip; palpiger four-elevenths longer than wide, sides parallel; mentum cordiform, anterior angles pronounced and acute; submentum extremely transverse, small and joint-like.

Prothorax narrower than the head, sides parallel; pronotum bearing a few scattered setæ; entirely chitinized except at the anterior margin and the sagittal line, which continues through the thorax; a large ventral sclerite present in front of the prothoracic coxæ.

Meso- and metathorax similar to each other, a little wider than but less than one-half as long as the prothorax, each with a pair of fairly large, irregular subtriangular sclerites and a lateral tubercle. A bifore spiracle present in each antero-lateral angle of the mesothorax while, corresponding in position to it, there is a small tubercle on the metathorax. Pro-mesothoracic and meso-metathoracic sclerites are present and are small, elongate, horizontal plates.

Legs about twice as long as the width of the thorax; segments beginning with coxæ bear the relation of 35, 12, 35, 25 and 15; tarsi well developed, claw-like, and each with two inner setæ, one dorsal to the other.

Abdomen with eight distinct segments, narrowed posteriorly, ninth and tenth rudimentary. The first seven tergites similar, each with two very much reduced, oval, chitinized patches on the proscutum, the first pair larger than the others, and four small but conspicuous tubercles in a transverse row across the posterior or second fold of the scutum, each bearing a seta. Each tergite consists of three transverse folds while the intersegmental membrane has only one; sternites with similar arrangement except that there is a longitudinal fold on each side of the three transverse folds. Seven pairs of rudimentary bifore spiracles and seven pairs of pleural appendages, equally long (0.48 mm.), on the first seven segments. A small dorsal tubercle at the base of the appendage. The eighth tergite represents the superior valve of the stig-

¹In *H. glaucus* the mandibles are asymmetrical. The left mandible possesses only a single inner tooth.

matic atrium and bears a large, chitinized plate, somewhat dome-shaped anteriorly. Caudal margin of the eighth tergite is slightly quadrilobed, each lobe with an unchitinized tip and several distal setæ.

Procercus well developed, its first segment prominent, with a chitinous band partly surrounding it and a distal tubercle as well as a small terminal segment, bearing an apical seta. Mesocercus fairly prominent, chitinized, two-segmented, each segment with an apical seta. The chitinous plate in front of the mesocerci distinct and with two transverse rows of setæ arranged in pairs; the posterior row with one pair and the anterior row with three pairs; median lobe of ninth tergite rounded and with a ventral chitinized plate which tends to wrap around it. Acrocercus situated below each lateral lobe of the ninth tergite, and with two terminal tubercles, each bearing a seta.

FULL-GROWN LARVA.—Length, 25–27 mm.; width at the thorax, 5 mm. General color is brownish above and dirty white below. The chitinized regions are castaneous. When about ready to pupate, it takes on a greenish gray coloration, probably due to the color pigment of the pupa. The head measures 3.25 mm. in width and 1.99 mm. along the mid-dorsal line. First segment of antenna slightly longer than in first stage, about one-fifth the second. Labro-clypeus inconspicuously crenate. Mandibles stouter, blunter and with the proximal inner tooth not noticeably bifid. Lobe of palpifer very rudimentary; dorsal surface of mentum with scattered setæ and four lateral spines which are more prominent; ligula very slightly divided at distal end. Seta in the caudal angle of the mesoscutum prominent. Prostyles or anal appendages not noticeably longer (1.2 mm.).

PUPA.—Length, 15 mm. with cerci (curled up); width at the thorax, 8 mm. Sea-greenish except whitish tubercles, styli, cerci and tip of abdomen. Whitish parts become brown as emergence time approaches and metathoracic wings fuscous.

Head smooth; two supraorbital styli present; two small oval raised areas on each side of the epicranial suture near the vertex. Pronotum smooth, its cephalic margin concave. Styli arranged as follows: three equally long styli,¹ curving backwards, in a transverse row at the anterior margin at each side; a group of three others similarly arranged but decreasing in length towards the middle, just inside the latter; three in a longitudinal row at each lateral margin; a transverse row of ten at the posterior margin (more slender and less recurved than latter); two transverse rows near the middle; the anterior row with four styli, the posterior with three. Meso- and metanotum with a pair of styli in a transverse row. Metathoracic pterothecæ visible from above. Tarsi not ending in prominent spines nor tibiæ spinous on the outer side. A transverse row of six motory styli on the first seven abdominal tergites, the outer one on each side mounted on a tubercle. Second to seventh pleurites each with a stylus or a tubercle. Eighth tergite with two small, rounded tubercles at the posterior margin on each side of the median line and each bearing a short terminal stylus. Ninth segment terminating in two, superficially annulate cerci, which are 2.85 mm. long, divergent, tapering and bifid at their tips. Spiracles raised and prominent.

¹These pronotal styli on the front margin and middle region have no terminal seta.

TROPISTERNUS Solier

Although the adults appear to be closely allied to *Hydrous*, the differences found in the immature stages tend to strengthen the validity of this genus. The adults differ from *Hydrous* principally in their smaller size and in the structure of the maxillary palpi. They are the most common members of the Hydrophilinæ and may be taken in almost any pool or lagoon. Although more active than most of the water scavengers the adults are easily captured by hand. *T. glaber*, *T. mixtus*, and *T. lateralis* are the representatives in this region. The former two strongly resemble each other but *T. lateralis* can easily be distinguished on account of the narrow yellow margin of the prothorax and elytra. *T. glaber* is by far the most abundant species. The genus is limited to America in its distribution.

Duges, 1884, was the first to give the characters of the immature stages. His descriptions of the larva and pupa of *T. lateralis*, collected in Mexico, were carefully done but his figures are not very helpful. Wickham, 1893, added the larva and pupa of *T. glaber*. The egg-case has apparently been unmentioned in literature. This seems strange as the cases, at least those of *T. glaber*, are very common at the commencement of the warm summer days.

Tropisternus glaber Herbst

Plate VII

The egg-cases cannot be mistaken; the horny mast is peculiar to the subfamily to which this genus belongs; the case is not as long as the naked case of *Hydrous* and is not wrapped up in a leaf as is the case of *Hydrophilus*. Instead, it is fastened to a leaf, blade of grass, or any kind of vegetation present at the surface of the water.

The cap covers one end of the case and the mast is firmly attached to it. There are from eleven to twenty-two eggs contained within and the time of incubation is six to seven days. The main dates of development of an individual observed in 1914 were as follows:

May 25, egg deposited in the case; May 30, larva emerged; July 1, burrowed; July 10, pupated; July 14, adult emerged.

The young larvæ were placed in an aquarium where they fed readily on entomostracans and small tadpoles. The different molts were not observed. Only a few larvæ reached maturity, as the weaker individuals were quickly eaten by the stronger ones. During the latter part of June and the first few weeks in July many full-grown larvæ were taken out-of-

doors at the edge of the pools under stones, débris, or even some distance from the shore on the surface of the alga-filled pools. The larvæ are found all summer but this first generation of the year is the most abundant. The second generation begins soon after the adults emerge, the greatest number of egg-cases of this generation being found the first part of August.

Pupæ were secured about the same time of the year within their cells an inch below the surface of the bank or under stones. When transforming indoors, many of the pupæ did not form a cell below ground but changed at the surface. The cells formed were about 12 mm. wide, 10 mm. high and nearly round. The earth in the terraria was only about three-quarters of an inch deep so that the larva could be observed forming the cells next to the glass. The constant squirming of the larvæ made the cell walls firm. The legs, especially the fore legs, helped materially in shedding the pupal skin. The tarsi are bent back and the tibiæ used in pushing the skin off.

Upon emerging, the head of the beetle, the middle of the pronotum (the edges lighter), the scutellum, and the legs were brownish in color. The elytra were yellowish white and the abdomen whitish. It colored very rapidly and in about ten hours was entirely black above but slightly brownish below.

EGG-CASE.—Whitish, except brownish mast. The measurements of case, which is figured, were 9.3 mm. long; 4.28 mm. wide at the cap end; 5.3 mm. wide at the other end; and the mast 4.8 mm. long.

NEWLY HATCHED LARVA.—Length, 4.8 mm.; width at the thorax, 0.84 mm. Light brownish (fulvous). Entire integument covered with fine short hairs.

Head ovate; fronto-clypeal suture well indicated at the sides; frontal sutures gradually converging and uniting to form a very short epicranial suture; frons raised in the middle, nearly triangular and with a transverse impressed line near its basal third; gula reduced, arched and semicircular but flattened posteriorly; gula sutures prominent and confluent. Cervical sclerites present.

Labro-clypeus nearly symmetrical, reduced, with very small teeth, usually five, in the middle and one on each side of the latter five but removed a little; a transverse row of six setæ just inside the margin. Lateral expansions of epistoma similar, rounded but somewhat straight in front, only barely exceeding the labro-clypeus with a row of inconspicuous setæ on the inner side and overlapping the bases of the mandibles.

Ocular areas in groups of six and arranged in parallel rows, the first three nearly vertically while the posterior three are horizontally placed. The sixth or outer one of the posterior row is distant from the fifth and in some specimens is rudimentary.

Antennæ extending forward about as far as the tips of the mandibles and beyond the first segment of the maxillary palpus; first segment longer than the following two segments taken together but stouter than in the other *Hydrophilinæ*; second segment slightly more slender and with several short setæ in the membrane preceding the third

segment; latter still more slender, a little stouter than the second and with several distal setæ in addition to a small, two-segmented, finger-like appendage.¹

Mandibles asymmetrical, prominent, elongate, sharply pointed at their tips, each mandible with two² inner toothed areas; the distal inner tooth on each well developed, bifid, their anterior margin minutely serrate, and their inner surface with a groove, which extends to the base of the mandibles; this latter groove separates the proximal inner tooth of each mandible into two, equal, flat teeth; those on the left mandible are much larger than those on the right and with a curved edge, which crosses the groove, slightly proximal to them.

Maxillæ with joint-like palpifer; cardo³ small; stipes slender, swollen at the base, slightly constricted in the middle, longer than the palpifer and palpus together and its inner surface with a row of five setæ; palpifer only slightly narrower than stipes but less than one-fourth its length; a chitinous finger-like appendage at its internodistal angle bearing a long seta and a microscopic lobe or sense-cone apically; palpus tapering and curving in slightly; the first segment small; the second about as long as the palpifer; the third a little longer than the latter and with terminal sense-cones.

Labium prominent, the palpus nearly attaining the distal end of the stipes, its first segment short, the second of the same width but much longer and with terminal sense-cones and setæ; ligula well developed, more than twice as long as the first palpal segment, cylindrical, only slightly tapering; palpiger a little longer than wide, slightly swollen; mentum subcordiform, anterior angles pronounced and sharply pointed; dorsal surface with numerous minute spines at its basal half; submentum extremely transverse and joint-like.

Prothorax nearly as wide as the head, angles slightly rounded; pronotum entirely chitinized except at the anterior and posterior margin and possessing a few scattered setæ besides a transverse row of six setæ in front and a transverse row of four in back; a large ventral sclerite present in front of the prothoracic legs. Sagittal line continuous throughout the thorax. Pro-mesotergal sclerites are present and are small, elongate and horizontal.

Mesothorax much shorter than the prothorax, about the same width and with a pair of fairly large, irregular, sclerites, each with a prominent seta caudally. Spiracular area with three small tubercles. A rudimentary bifore spiracle present in each externo-frontal angle.

Metathorax similar but slightly narrower and shorter and its sclerites more irregular caudally. A small pleural appendage present.

Legs more than twice as long as the width of the thorax; segments beginning with coxæ bear the relation of 16, 7, 16, 12, and 9; tarsi well developed, claw-like and each with two inner setæ, one proximal to the other and smaller.

Abdomen with eight distinct segments narrowed posteriorly, ninth and tenth rudimentary. The first seven tergites similar, each with two very much reduced, oval, chitinized patches on the præscutum, the first pair larger than the others, and four small but conspicuous tubercles in a transverse row across the posterior fold of the scutum, each bearing a long, colorless seta. Each tergite consists of three trans-

¹Wickham, 1893, considers this appendage as one-segmented but remarks that it appears to be two-segmented.

²Duges, 1883, describes *T. lateralis* as possessing only one inner tooth. The terminal segment of the maxillary palpus is also small and cone-shaped.

³Wickham, 1893, said that he could not find the basal segment in his specimen although Duges had apparently observed it in *T. lateralis*.

verse folds while the intersegmental membrane has only one; sternites with similar arrangement except that there is a longitudinal fold on each side of the three transverse folds and a fourth indistinct transverse fold was observed in some specimens. The biform spiracles at the tip of small tubercles. Both the epipleurite and hypopleurite bear a tubercle. The transverse row of tubercles is lacking on the second fold of the sternite but a single prominent tubercle is present on each side of the third fold as well as one behind the middle of the longitudinal fold.

The eighth tergite represents the superior valve of the stigmatic atrium and bears a large, shield-shaped, chitinous plate, which is slightly emarginate at the middle of its anterior border but more prominently so just behind the two middle lobes of the caudal margin of the eighth tergite. The structure of the atrium is very close to that of *Hydrophilus*. It differs from the latter principally by the fact that the two middle lobes of the hind margin of the superior valve are more distinct resembling the mesocerci and that the two anterior setæ of the plate in front of the cerci are set farther apart. The median lobe of the ninth tergite with two distal setæ. The prostyles are short, not exceeding the sides of the body, broad, rounded, and depressed.

FULL-GROWN LARVA.—Length, 14 mm.; width at the thorax, 3.2 mm. General color brownish above and dirty white below; chitinized regions reddish brown. Head dorsally with a yellow stripe on each side; ventrally with a median and two lateral pairs of yellow stripes; measures 2 mm. in width and 1.44 mm. along the mid-dorsal line. First segment of antenna longer in proportion than in the first instar, more than four times the second segment. Labro-clypeus nearly straight, often slightly crenate, and some specimens retain the most lateral tooth of the first instar on each side, but it is very inconspicuous. Mandibles with the outer spur of bifid inner tooth lacking. Lobe of palpi very much reduced; dorsal setæ of mentum (about fourteen) arranged somewhat in a transverse ellipse; externo-frontal angles rounded but prominent and with a small outer seta; tubercles of abdomen prominent and each bearing a group of long, slender, terminal setæ.

PUPA.—Length, 12 mm. (curled up); width at its thorax, 5.6 mm. Entirely whitish except reddish brown eyes.¹ Head smooth, no supracorbital setæ, oval, raised areas on each side of the epicranial suture near the vertex very small. Pronotum smooth with middle lobes not prominent. Motory styli are long, fleshy and annulate, each bearing a terminal seta, slightly recurved and arranged as follows: three in a transverse row on each side near the anterior margin; four in the middle just back of the anterior margin, the two inner ones set back a little; six in a transverse row at the posterior margin (no corner styli); two on the basal half of each side; and two in a transverse row across the middle. Meso- and metanotum with a pair of transverse styli; scutellum well marked; metasternal spine long. Inner spur of metatibia very prominent. Tarsi not ending in prominent spines nor tibiae spinous on the outer side. Metathoracic pterotheca visible from above. First to seventh tergites with a transverse row of four styli, second to seventh pleurites each with a stylus. Eighth tergite with two very small indistinct lobes at its posterior margin on each side of the median line and each bearing small stylus. Ninth segment terminating in two crooked, fleshy, superficially annulate cerci about 1.45 mm. long. Cerci diverge as far as their

¹A fresh pupa showed the eyes entirely white except the six pigment-spots of the ocular areas, which were grouped at hind margin of the head.

middle and then converge. They are slightly bifid and sharply pointed. On the outer side of the distal third are two small spines. Abdominal spiracles (second to sixth) large, uncovered and the area about them well chitinized.

***Tropisternus sublaevis* LeConte**

A specimen of this species was examined at the National Museum. It is very close to *T. glaber*. The proximal inner teeth of both mandibles are more reduced and the basal ridge of left mandible is lacking.

Hydrous Leach

The above generic name will doubtless be confusing to many because our representatives have for so long a period been known under the genus *Hydrophilus*. Here are included the largest beetles of the family and, in Ithaca, only one species is to be found, namely, *H. triangularis*. This is well known to collectors and because of its large size, measuring over thirty millimeters in length, can not be mistaken. Its specific name is evidently due to the triangular spots of yellowish brown hair on the abdominal sternites.

Adults have been collected during the warm spring and summer months under electric lights, toward which they often fly in large numbers. One specimen was captured as late as November 1 under an arc light. The most rapid swimmers of the family are included in this genus. It is clearly seen that their bodies are well adapted for gliding through the water with the least possible resistance.

European authors have paid a great deal of attention to *H. aterrimus* and *H. piceus*, especially the latter, not only to their life history but also to their biology in its various phases. The earliest mention of the larval and pupal stages was made by Frisch as far back as 1721 but his unique error of describing the larva upside down and therefore ascribing dorsal legs to it takes away part of its value. Miger and Lyonet follow about a century later and both papers are worthy of commendation. The life history of *H. aterrimus* given by Schiödte is presented in the usual careful way of the author.

The most complete work on the only American species considered is that of Dr. Robert Matheson of Cornell University, published in 1914. He has very carefully followed the entire life history of *H. triangularis* through all its stages from the egg to adult. Garman's paper in 1881 on the egg-case and larva was well written but did not include the entire life history. It was supplemented by Riley's paper in the same year.

Hydrous triangularis Say

Plate I, Figure 7; Plate VIII

It hardly seems necessary to go into the biology of this species. However, the main events occur as follows. The egg-cases are found mostly in June, and, although always attached to floating leaves or other débris, have never been reported as fastened to living plants. Over one hundred eggs are enclosed within it and the larvæ when newly hatched are very ungainly as compared with the full-grown larva. The usual two molts take place and the pupa appears in about one month. The duration of this latter stage is about eleven days.

EGG-CASE.—Light brownish with its mast and plate at base of mast almost black. It measures 24 mm. long, 15 mm. high, and about 22 mm. wide. The horn-like process, which arises from the cap end of the case, is almost at right angles with the upper side of the case and is usually 7–8 mm. long. Below the plate is a lunar-shaped opening which leads into a chamber below the eggs.

NEWLY HATCHED LARVA.—Length, 8 mm.; width at the thorax, 1.7 mm. Light brownish with appendages whitish darkening with age. Integument with fine dark hairs.

Head, without mouth-parts, 1.14 mm. long dorsally and 1.82 mm. long ventrally; 2.1 mm. in width; broadly ovate, large, depressed, strongly elevated; fronto-clypeal suture well marked; frontal sutures widely separated, converging only slightly and not uniting to form an epicranial suture; gula fairly prominent, arched, semicircular behind; gular sutures confluent and distinct.

Labro-clypeus reduced, with its anterior margin slightly concave and bearing a few microscopic projections towards each side. Lateral expansions of the epistoma similar, acute, not prominent.

Ocular areas in groups of six, elongate and arranged in two parallel rows, the first three nearly vertically while the posterior three are horizontally placed. The sixth or outer one of the posterior row distant from the fifth.

Antennæ three-segmented, exceeding the right mandible by almost the length of the terminal segment, and left by its last and half of its penultimate segment; first segment longer than the second and third together, almost as long as the stipes, bent inwardly near the base and fringed on the inside, except the basal third, with slender setæ; second segment swollen distally and not quite as long as the third, which bears no distinct terminal sense-cones.

Mandibles asymmetrical, prominent, sharply pointed at their tips and with their inner surfaces grooved; each mandible with a single inner tooth, the inner tooth of the right mandible with a large tooth on its anterior margin forming an unequally bifid tooth; the left mandible stouter and shorter than the right and with a membranous area in the region of the molar surface.

Maxillæ with joint-like palpifer; stipes slender, slightly bowed, longer than the palpifer and palpus together and its inner surface with a row of four stout setæ; palpifer with a chitinous finger-like appendage at its interno-distal angle; about the same length as each of the palpal segments but slightly wider; terminal segment of palpus with no distinct sense-cones. Articulating maxillary piece well developed.

Labium prominent, almost attaining the tip of the left mandible; submentum transverse and hinge-like; mentum longer than wide, arched below, its sides at basal half slightly concave but at its distal half convex, the fronto-external angles produced forward and prominent; palpiger much narrower than the mentum, its sides diverging anteriorly; ligula somewhat thimble-shaped, about the same size as the first palpal segment; the second segment of the palpus more than twice as long as the first and slightly convex on the outer side.

Prothorax narrower than the head; anterior margin nearly straight; proscutum represented by two, fairly large, somewhat triangular sclerites. Sagittal line present throughout thorax. Mesothorax slightly shorter than prothorax but just as wide; the mesoscutal sclerites more triangular and smaller. A small bifore spiracle¹ present in each spiracular area. Metathorax similar to latter but not quite as long.

Legs very long, about two-fifths longer than the thorax is wide; coxæ nearly as long as the femora, the latter with swimming fringes; tibiæ shorter than femora and three-sevenths longer than tarsi. The tarsi bear two inner setæ, one distal to the other; tarsi claw-like and well developed.

Abdomen with eight distinct segments, narrowed caudally, ninth and tenth rudimentary. The first seven tergites similar and each divided into three transverse folds, while the intersegmental membrane has only one. The second scutal fold bears a transverse row of four small tubercles. Epipleurite and hypopleurite each surmounted by a small tubercle, not distinctly separated but together forming an elongate lateral lobe. First five sternites with three transverse folds and a longitudinal fold on each side of them. Eighth tergite about as long and wide as the intersegmental membrane preceding. The dorsal region represents the superior valve of the stigmatic atrium and bears a reduced plate, the slender anterior arms of which enclose a median, elongate, non-chitinized area. The caudal margin of the eighth tergite is minutely crenate towards the sides and is rounded in the middle. The rudiments of the four lobes found in other Hydrophilinæ are weakly indicated. There are two small tubercles, one below and on each side of the middle lobe of this hind margin. Procerci fleshy and quite prominent. The mesocerci are fairly prominent, as well as the acrocerci. The median lobe of the ninth tergite is slightly bilobed. Lateral lobes not prominent. The prostyles, belonging to the tenth segment, are nearly as long as the seventh and eighth segments together (1.44 mm.) and are superficially annulate.

FULL-GROWN LARVA.—Length, 40–54 mm.; width at the first abdominal segment, 9–12.5 mm. General color grayish or dirty whitish except reddish brown head, sclerites, and legs. Head 6.5 mm. wide; 5 mm. long below; 3.1 mm. long above. Antennæ four-segmented,² a small segment about one-third the length of the third segment having appeared between the first and second segments of the first-stage antenna. Lateral expansions of the epistoma not prominent. Mandibles with tips and inner teeth blunt. Terminal segment of maxilla only about half the penultimate in length. Ligula dome-shaped, much shorter than the first palpal segment, which is a little more than one-half the second segment of the maxillary palpus. Dorsal surfaces of the mentum and palpiger with a few scattered setæ.

¹Matheson described a pair as present on the metathorax also but none were seen in the specimens which I examined.

²D'Orchymont considers that Schiödt was mistaken when he called the antenna of *Hydrous* four-segmented. There are surely four in *H. triangularis*.

Thoracic segments wider than the head. Folds and lobes of whole body much more distinct than in other stages. Legs about five-sixths as long as the thorax is wide. Abdomen spindle-shaped.

PUPA.—Length, 24 mm. with cerci (curled up); width at its thorax, 14.5 mm. Whitish. Head smooth, only one small posterior supraorbital stylus noted; two small, oval, raised areas on each side of the epicranial suture near the vertex. Pronotum smooth, its cephalic margin concave. Styli arranged as follows: three long styli, curving backwards, in a transverse row at the anterior margin on each side; eight shorter ones near the posterior margin, besides two very small ones just inside the inner two styli; a few other scattered ones. Mesonotum and metanotum with a pair of styli in a transverse row. Scutellum well marked. Metasternal spine long. Inner spur of metatibiæ very prominent. Metathoracic legs long nearly attaining the end of the body. Tarsi not ending in prominent spines nor tibiæ spinous on the outer side. Metathoracic pterothecæ visible from above. First to seventh abdominal tergites with a transverse row of four styli, the outer one on each side mounted on a tubercle. The styli just behind the spiracles longer than the others and curved backwards. Second to seventh pleurites each with a stylus. Eighth abdominal tergite with two small rounded tubercles at the posterior margin on each side of the median line and each bearing a short terminal stylus. Ninth abdominal segment terminating in two superficially annulate cerci about 2.5 mm. in length and with a prominent short, ventral spine between their bases. Abdominal spiracles oval, uncovered and prominent (second to sixth visible).

8. Hydrobiinæ

Eggs usually enclosed in a silken case with a prominent projection but sometimes laid in a mass with a loosely applied covering of silk (*Cymbiodyla* and *Paracymus*) or held on the under side of the body by the elytra (*Epimetopus*, *Chaetarthria* ?) or hind legs (*Helochares*).

Larva with head elevated. Antennæ with points of insertion situated farther from the externo-frontal angles than those of the mandibles; second segment with an antennal appendage. With or without an epicranial suture; ocular areas flat, elongate, in groups of six, closely aggregated; labrum and clypeus both reduced and united, the anterior margin more or less toothed; mandibles prominent, sharply pointed and with inner teeth; maxillæ palpiform and stipes with a rudimentary inner lobe. Labial palpi longer than in other subfamilies; the second segment distinctly longer than the first. Ligula present except in *Berosus* and *Laccobius*; labium and maxillæ inserted at the front margin of the under side of the head¹ and not attaining the occipital opening. Eight complete abdominal segments and a rudimentary ninth and tenth; the chitinization is entirely lacking, except the dorsal plate of the eighth segment and chitinized patches on the præscuta. Cerci two-segmented but reduced (absent in *Berosus*). Type of breathing is pseudo-metapneustic except in *Berosus*, which possesses tracheal gills and a rudimentary stigmatic atrium. All genera have poorly developed bifore spiracles.

¹Vestiges of furrowed condition in *Berosus* and *Laccobius*.

LACCOBIUS Erickson

This genus is evidently represented by one species and a variety in New York State but the variety has not been described to date. The more common or silvery species is apparently the one which Randall named *agilis* and was first recorded from Maine. The other, which seems to be a new variety, is less common and of a general brown color lacking the pale triangular space in front of the eye. Both species seem to have a great diversity in size. *L. agilis*, although very abundant in its habitat, has been little collected in Ithaca, only three specimens having been recorded to the date of my first observations in the fall of 1913. It is found frequently in Cascadilla Creek either on mud flats or on stone ledges which border its waters. Specimens are most easily collected by washing the vegetation and shore with the creek water, using the hand as a dipper. When thus disturbed, the little beetles will be noted swimming speedily towards the shore and presently observed burrowing in the mud or hiding in the vegetation until they are entirely concealed from view. The most abundant vegetation in their environment seems to be the alga, *Cladophora*, which is especially common in our swiftly flowing streams.

The brown variety frequents mud holes and swampy lands but, with that exception, its habits are very similar. The life history of this genus is practically unworked¹ except by d'Orchymont, who gives what he considers the generic larval characters of *Laccobius*² sp. ?, an immature specimen of which he obtained. This is accompanied by a dorsal view of the head.

Laccobius agilis Randall

Plate IX

The egg-cases of the brown variety have not been taken as yet in the field but those of *agilis* are very abundant at certain seasons of the year. They have been collected in April, May, June, and July. The most natural place for the cases is apparently at the water line in *Cladophora* or attached to the roots or blades of grass. They are frequently attached to the rock-ledge itself and, in such condition, are hard to remove without breaking open the case.

¹Dr. Adam Böving, however, gave me the following data as to the rearing of *Laccobius*: "Dr. Wessenberg-Lund has not yet published anything about it; Schlick has published a note in the Danish Entomologiske Meddelelser Vol. 4, 1894, p. 304 and also in a later volume, as far as I remember Vol. 6; in the same periodical Vol. 5, 1895, p. 12, you will find a note that E. Rosenberg has taken and reared the *Laccobius* larva to adult."

²It differs mainly from *L. agilis* in that the right mandible possesses only two inner teeth. This is also true of the undescribed larva of *L. minutus*.

From two to eleven eggs are in each case and these hatch in seven to eleven days. When leaving the case, the larva seems to select no particular place of exit. Specimens have been noticed emerging from a hole in the egg-case proper; others from an opening made at the outer edge of the basal cavity of the filament (see Plate IX). Many larvæ have been collected. They may be observed on the *Cladophora* and stones just where the water laps the shore, half in water and half out, as is the customary position of most pseudo- and metapneustic Hydrophilidæ. The number of instars seems to be three.

About the middle of June 1915 several fairly mature larvæ, which were hatched from eggs taken April 29, were placed in the usual terrarium but, as they did not seem quite ready for pupation, they were replaced. On June 22, while on a special trip to the best collecting grounds of *Laccobius*, about fifteen larvæ were taken. The largest of these were placed in the terrarium at the same time as one of the reared larvæ but in different receptacles. On the morning of June 30 one of the latter lot had pupated as well as one of the larvæ of April 29. Upon comparing the larval skins and pupæ, they proved to be identical and, so, one pupa was allowed to come through but the other was preserved with its larval skin. Thus, the complete life history was secured. One of the larvæ pupated on the surface of the earth, while the other made a cell (6 mm. long, 3 mm. wide, and 3 mm. deep), just below the surface. The dates of development were as follows:

April 29, egg-case found; May 4, larvæ hatched; June 30, pupated; July 3, adult emerged.

Soon after emerging the adult's head, prothorax, and scutellum were colored very dark green, except the lateral margins of the pronotum, which were silvery gray with dark green or blackish spots sparsely distributed. The coxæ, trochanters, and femora were gray, but the tibiæ and tarsi were luteous. The exact time before complete coloration took place was not noted, but it was longer than with other species.

EGG-CASE, without its filament, nearly spherical, often a little broader than long, its size varying as does that of the filament. Measurements show the case proper to be from 1.4–1.6 mm. in diameter and the filament from 7–10 mm. in length. The latter is continuous with the covering of the case and is therefore hollow, the cavity at its base being quite large, as figure 11, Plate IX, indicates.

NEWLY HATCHED LARVA.—Length, 2 mm.; width, 0.288 mm. Whitish (transparent at first), except the chitinous portions, which are light brown darkening with age. Integument dotted with slightly recurved spines arising from minute tubercles.

Head quadrangular, elevated slightly; labro-clypeal suture weakly indicated by a crease in the integument; frontal sutures parallel, extending to the caudal margin of the head and not uniting to form the epicranial suture; frons quadrangular; hypo-

stomal margin prominent and there is a furrow in front of it but the labrum and maxillæ are united at the anterior margin; gula reduced; the gular sutures fairly prominent and confluent and its anterior margin with two long setæ on each side of its median line. The cervical sclerites present.

Labro-clypeus asymmetrical, irregularly toothed in the middle with three teeth and with two, prominent, blunt setæ projecting from the ventral side. Lateral expansions of epistoma differing greatly; the right rounded, overlapping the base of the right mandible; the left overlapping the left mandible and rounded but bearing a row of stout setæ which become shorter toward the median line (five or six are very prominent).

Ocular areas in groups of six but rather indistinct. They are arranged in two parallel rows, the outer one of the posterior row a little out of line and more anterior.

Antennæ fairly stout; the first segment about two-thirds as long as the second, slightly constricted in the middle and bearing at least two dorsal sensory pits; second swollen a little and bearing a small, colorless, finger-like antennal appendage in addition to the sense-cones at the latter's base, and a long inner seta, arising from a tubercle, as well as a few less prominent ones; third segment very small, almost as wide as long, a little longer than the appendage of the second segment, and bearing three long setæ and several sense-cones at its extremity.

Mandibles asymmetrical, fairly prominent and stout, sharply pointed at their tips, and toothed on the inner side; right mandible bears three inner teeth, decreasing in size from the cephalic to caudal one; the left has two toothed areas on the inner side, both of which present a pectinate region dorsally, in addition to a tooth.

Maxillæ with joint-like palpifer; stipes large, swollen, tapering slightly from base to apex, longer than the palpifer and palpus together and its inner surface provided with short, stiff setæ, and several longer stout setæ at intervals; the more slender setæ are present at the externo-distal angle; palpifer small, a little wider than long, bearing an inner rudimentary lobe, possessing a seta and sense-cones, below which is a slender seta; palpus with first segment about one-half the second while the third is a little longer than the first two and more slender and more cylindrical; the terminal segment possesses a group of sense-cones at its tip; articulating piece of maxilla well developed.

Labium small and with only its palpi exceeding the labro-clypeus; mentum and palpiger very small; both segments of the palpus are cylindrical, the second about three times as long as the first, more slender and with its tip possessing a number of sense-cones; ligula absent; palpiger has two setæ on its anterior border near the median line; submentum very indistinct.

Prothorax very slightly narrowed in front, larger than the head; pronotum entirely chitinized, except the sagittal line, with a transverse row of setæ (about ten) just a little posterior to the cephalic margin, several others on the sides. Meso- and metathorax a little wider and shorter than the prothorax. Mesoscutum and metascutum both represented by two subtriangular and very much reduced sclerites, each having a seta in their caudo-medial angle. The mesonotum has two smaller oval sclerites¹ just lateral of the median line and posterior to the cephalic margin. The spiracle at the tip of a little conical tubercle² in each antero-lateral angle of the mesothorax two-fifths as long as the thorax is wide.

¹Probably homologous with the cervical sclerites.

²Tracheo-branchies of d'Orchymont.

Legs fairly long, with tibiae nearly as long as, but a little more slender than, the femora; femora shorter than the small coxae; tarsi well developed, claw-like, almost as long as the tibiae, with two inner setae one distal to the other.

Abdomen with eight prominent segments, slightly narrowed caudally, ninth and tenth rudimentary. The first seven similar, each with two very much reduced, oval, chitinized patches on the praescutum near the cephalic margin on each side of the median line, and four prominent tubercles in a transverse line across the posterior fold of the scutum, each bearing a seta. Each tergite seems to consist of a praescutum, scutum divided into two transverse folds and posteriorly a very narrow scutellar fold that continues to the spiracular part of the tergite; sternites have similar corresponding folds. The eighth tergite represents the superior valve of the stigmatic atrium, bears a large chitinous plate,¹ which is about as broad as long. The caudal border of the valve is chitinized in part, possesses setae and presents a bilobed appearance. Procercus one-segmented,² subconical with a chitinous band on the inside and a group of three setae arising dorsally from tubercles on the apical half. Mesocercus two-segmented and chitinous, the first segment elongate, dome-shaped, bearing a central dorsal seta; the second very small, papilliform, and bearing a terminal seta. Between these two segments in the membrane there are several sense-cones.

Ninth tergite is divided into three lobes, two lateral and one median. The median lobe is irregularly dome-shaped with a chitinous plate nearly covering the upper surface while the lateral lobe possesses a chitinous region from which arises two setae mounted on tubercles. Two pairs of setae, arising from tubercles, are present on the membranous area just lateral to the plate, the anterior pair being contiguous with the plate. A ventral pair may be seen through the membrane, anterior and in line with the other two. Acrocercus present on the under side of the lateral lobe and terminates in two setae mounted on tubercles.

FULL-GROWN LARVA.—Length, 5.8 mm.; width at the second to fourth abdominal segments, 1.5 mm. The general color is grayish brown or dirty white. The head, which is 0.3 mm. in length and a little less in width, is often retracted under the pronotum as far as the ocular areas. First segment of antennae little less than the second in length. Finger-like appendage of second segment about one-half the size of the third, which has become more elongate. Mandibles much stronger. The smallest inner tooth³ of right mandible is smaller in comparison with the other teeth. Maxillae more developed; stipes larger and considerably longer than palpus and palpifer together. Legs not as long as thorax is wide. Viewed from the side, there seem to be three lateral regions or tubercles on each abdominal segment; the dorsal and ventral lateral regions of the intersegmental membrane are reduced so that only the middle one is prominent.

PUPA.—Length, 3.6 mm. (curled up); width at its thorax, 2.9 mm. Whitish. Head smooth and bears two supraorbital styli on each side. Pronotum smooth, its cephalic margin lobe-like in the middle. The styli are arranged in transverse rows as follows: ten at the anterior margin, four in the middle at the posterior margin, the two middle ones being shorter than the other eight and the most lateral one on each

¹A central colorless seta noted in some specimens and in *L. minutus* the anterior border of the plate is emarginate.

²D'Orchymont, because a terminal papilliform tubercle bearing a seta is present, considers that it may be two-segmented. The condition in *Hydrophilus obtusatus* tends to verify his opinion.

³Indicates a tendency to disappear. *Laccobius minutus* has only two inner teeth on right mandible.

side a little anterior. Mesonotum and metanotum with a pair of transverse styli. Inner spur of metatibia fairly prominent. All tarsi ending in a spine and all tibiae spinous on the outer side. First to seventh tergites with a transverse row of four subequal styli; the outer one on each side arising from prominent tubercles; second to seventh pleurites each with a stylus; eighth segment has two, small, cercal-like lobes, projecting dorsally. Ninth segment has a pair of cerci, which are about four times as long as the latter lobes and project backwards, diverging about 45°. The externo-caudal angles of the ninth segment are prominent and acute. The spiracles are exposed and well defined.

BEROSUS Leach

Schiödte gave the complete life history of *B. spinosus* and later the larval differences of *B. signaticollis*. Brocher described the egg-case and young larva of *B. æriceps* (= *signaticollis*) and, although he did not rear it, considered that it could be no other species because of its size.

At least two species, *B. peregrinus* and *B. striatus*, occur in the vicinity of Cayuga Lake and doubtless others would be found if more time could be devoted to their study. These two are fairly distinct; the latter is separated from the former by its usually larger size and by the two small teeth, instead of only one, at the middle of the notch of the fifth abdominal sternite. The carination of the abdominal sternites of the male *peregrinus*, often used as a character of separation, seems to be quite variable in the specimens examined.

The beetles may be taken from early spring until late fall but are most frequent in May and late August. They are hardly ever taken in swift waters but inhabit small pools with an abundance of moneywort, *Chara*, *Elodea*, cut-grass, alga, etc. The fact that they are good swimmers requires the use of nets, in contrast to hand collecting so profitable for most of the other genera. The net must be drawn through the water rapidly for, as soon as disturbed, the beetles quickly dodge down to the bottom of the pool and in a moment are buried in the mud. At times many specimens may be gathered by pulling the vegetation out of the water quickly and looking it over carefully. They do not easily escape when thus taken, as they are very clumsy when out of water.

In the aquarium, they were observed feeding on the decaying leaves of moneywort, attacking both the upper and under side and eating holes entirely through. While watching them feeding, a peculiar, almost incessant action was noted. The beetles, holding on to the plants with their two anterior pairs of legs, kept sweeping the swimming hairs, which fringe the tarsi and tibiae of the hind legs, down and forward across the film of air covering the abdomen. Just what the function of such a

procedure may be is a question. Possibly it may serve to aerate the film of air, thus accounting for their ability to remain below the surface almost indefinitely. Stridulation is very pronounced and Brocher considered it in detail.

About thirty egg-cases were laid the middle of April in the aquarium on alga and moneywort below water. They somewhat resembled miniature chestnuts in form, and each contained from two to four eggs.

The first egg-cases noted out of doors were found May 9 in a small pool on South Hill. The submerged *Carex* was spotted with the white cases and apparently the dead plants were preferred. In a pool where no vegetation was present the cases were laid upon the under side of sticks and stones. Although more abundant in the egg-laying seasons, common to the family, yet the cases were found during the entire summer.

The larvæ on hatching break through the case at no particular place. However, the most common point of exit was between the base of the flap and the cap. The larvæ were very weakly chitinized in comparison with the larvæ of other genera. They spend most of their time crawling through the strands of algæ or in the débris at the bottom of the aquarium. The larvæ are the most difficult of the whole family to locate, due primarily to the fact that they breathe by gills. They live at the bottom of the ponds and farther from the shore than is the custom of the other larvæ. The débris clings to them and they, therefore, closely resemble their surroundings.

***Berosus peregrinus* Herbst**

Plate X

Several egg-cases of *B. peregrinus* were found the latter part of July and the spinning and egg laying proceeded in the following order.

1. An under layer of compact silk, composed of criss-cross strands, laid down continuous with the flap.
2. One egg deposited lengthwise towards one side and covered with a loosely applied silk.
3. Second egg placed near the opposite side, parallel to the first egg and covered with a loosely applied silk.
4. Third egg laid between the first two eggs.
5. A cap of compact silk, composed of criss-cross strands of silk laid tightly over the egg-case proper.

EGG-CASE, as a whole, somewhat chestnut-shaped. The cap end is flat with a narrow flare outside the egg-case proper; and the cap, which covers this surface, is continuous with the slender filament that extends upwards. The other end is rounded.

The case proper measures 1.6 mm. high, 1.2 mm. wide, and 0.323 mm. long. The filament averages about 4.5 mm. long, its width of 0.13 mm. is usually constant and its sides are parallel.

NEWLY HATCHED LARVA.—Length, 1.9 mm.; width at its thorax, 0.32 mm. Whitish, with chitinated areas very slightly light yellowish. Integument dotted with minute setæ.

Head ovate, elevated; fronto-clypeal suture very indistinct; labro-clypeal suture fairly well indicated; frontal sutures gradually converging as far as the posterior third and then slightly diverging, not uniting to form an epicranial suture; gula reduced, polygonal, posteriorly somewhat rounded; gular sutures contiguous for a long distance; labium and maxilla inserted at the anterior margin of the head but the signs of the groove are still present and the hypostomal margin distinctly marked off; cervical sclerites present.

Labro-clypeus small, projecting forward rather prominently, arched, with seven small teeth and four equidistant setæ. Lateral expansions of epistoma differ greatly; the right rounded, reduced and not exceeding the labro-clypeus; the left prominent, exceeding the latter, rounded and bearing a row of setæ on its anterior margin.

Ocular areas in groups of six and closely aggregated, oval, arranged somewhat in a circle, each area equidistant from the other except the sixth area which is about twice the distance from the first area than it is from the fifth.

Antennæ short, not exceeding the mandibles, with their points of insertion widely separated but inside those of the mandibles; first segment a little longer than the second, constricted at its basal half and with a small finger-like appendage, provided with colorless apical setæ, at its interno-frontal angle; second segment swollen, only slightly narrowed distally and bearing a small, colorless, finger-like antennal appendage, which is nearly as long as the third segment; the latter small, a little longer than wide, and with terminal setæ and sense-cones.

Mandibles asymmetrical, prominent, sickle-shaped, sharply pointed at their tips, and toothed on the inner side; right¹ mandible with two inner teeth, the distal tooth much larger than the proximal one, and the vestige of a third more proximal tooth apparently represented by a minute spine; left mandible slightly notched on the inside towards the tip and with a complicated set of inner teeth, the distal one the largest and triangular; molar area with a small distal, spine-like projection.

Maxillæ with joint-like palpifer; stipes large, swollen, tapering very slightly, longer than the palpifer and palpus together and its inner surface provided with a row of five, stout, equidistant setæ; two slender setæ near the externo-distal angle; palpifer short, much wider than long, bearing an inner rudimentary lobe, provided with a long seta and a sense-cone, below which is a stout seta; palpus tapering; the first segment only about one-half the palpifer in length; the second much longer and with an externo-distal seta; terminal segment two-sevenths shorter than the latter and with distal sense-cones, in addition to an inner seta.

Labium small, with only the palpi exceeding the labro-clypeus; submentum small and transverse; mentum transverse with its anterior angles rounded; palpiger rather quadrate, narrower than latter and about the same length, slightly divided anteriorly in the middle and each half bears the two-segmented palpus; first segment of latter short, the second segment nearly three times as long and with terminal setæ; ligula absent.

¹*B. spinosus* has a similar right mandible.

Prothorax rounded at the sides, about the same width as the head; anterior and posterior of pronotum non-chitinized; rest weakly chitinized except along the sagittal line; prosternum weakly chitinized in front of the coxæ; mesothorax and metathorax about equal to each other in size, shorter but slightly wider than the prothorax. Sclerites are not discernible. The pleural lobes are each surmounted by a seta arising from an elongate cylindrical structure (see figure 5, Plate X). A spiracle present in each externo-frontal angle of the mesothorax.

Legs long, about one-half again as long as the thorax is wide; coxæ transverse; femora and tibiæ about the same length; tarsi well developed, claw-like, one-fourth shorter than the tibiæ and with two inner setæ. The two anterior coxæ are closer together than the four posterior coxæ, which are about the same distance apart.

Abdomen with eight distinct segments, narrowed and slightly lengthened posteriorly, flattened above and arched below. The first seven tergites similar; indistinctly divided into two folds, while the intersegmental membrane has only one fold; each pleurite protrudes and bears a long, slender, tracheal gill, the length of these seven pairs of gills increases posteriorly. The second scutal fold has a transverse row of four setæ, each arising from an elongate cylindrical structure (similar to those on the pleurites of the thorax). Another seta, with such a structure at its base, present on the dorsal side of each gill and slightly removed from the base of the gill. Spiracles are at tip of small tubercles. The sternites have similar folds but no tubercles are discernible. Eighth segment short, cylindrical and with two small spiracles¹ on the middle of its dorsal surface and a few posterior setæ. The anus terminates this segment.

FULL-GROWN LARVA.—Length, 5.6 mm. (not counting the gills); width at the second abdominal segment, 1.68 mm. Pale yellowish with chitinized areas yellowish brown. Head, 0.576 mm. wide, 0.36 mm. along the mid-dorsal line. First antennal segment much longer and about one-half again as long as the second segment. The whole antenna more slender. Labium very indistinct. Body gradually widened as far as the second abdominal segment and then narrowed. Segmentation is much more pronounced as is the chitinization also. Mesothorax with two reduced subtriangular sclerites. Two small horizontal pro-mesothoragal sclerites present. Mesothoracic spiracles distinct and meso- and metapleurites each with a prominent wart-like tubercle corresponding in position to the gills of the segments. Præscuta of metathorax and first four abdominal segments visible. Legs much shorter, not as long as the thorax is wide.

Peculiar structures noted at base of setæ on posterior fold of abdominal scuta replaced by small but distinct, rounded tubercles. The gills are much shorter in proportion to the body and possess no dorsal seta near their bases.

PUPA.—The characters used by Schiödt in his pupal key are as follows: "Motory styli of abdominal tergites in fours; abdominal tergites with a small lateral tubercle on each side; spiracles not concealed; abdominal pleurites not distinctly separated from the tergites; styli of pleurites very short and conical; lateral styli of abdominal tergites very long and slender; prothoracic styli long and slender; cerci elongate, tapering, crooked and distally multiannulate." The figure shows twenty-six pronotal setæ or two more than is characteristic of the *Hydrobiinæ*.

¹The position of these spiracles recalls the position of those found in the pseudo-metapneustic *Hydrophilidæ* and probably indicates the degeneration of that type.

Berosus striatus Say

The stages of this species are very close in form to those of *B. peregrinus* and a separate description is unnecessary. The left mandible of the larva is quite similar to that of *peregrinus* but the right one has only the distal inner tooth well developed. The other two teeth are very rudimentary. As both the species belong to the same subgenus, *Berosus*, this character evidently is not one of subgeneric significance. Larvæ in the National Museum of *B. æriceps* (= *signaticollis* Charp.), which belongs to the same subgenus, possess the *peregrinus* type of mandible but have the labro-clypeus untoothed, rounded and short. The labro-clypeus of *B. striatus* is similar to *peregrinus* but the number of teeth varies from three to six.

CHÆTARTHERIA Stephens

Four species have been described from this country. *C. atra* LeConte, 1883, however, is the local species near Cayuga Lake and is very rare. In the field it could easily be mistaken for *Ancæna* and *Paracymus* but is usually smaller and noticeably hemispherical in shape. Closer examination clearly distinguishes it. The first segment of the antennæ is elongate and flattened. The ventral plates, fringed with appressed setæ and concealing the first two abdominal sternites, constitute the most striking characters of this genus.

The life history has not been observed. The structure of the abdomen possibly indicates that the egg-cases may be held on the ventral side of the female, somewhat in the same manner as in *Epimeptopus*.

HYDROBIUS Leach

One experiences little difficulty in separating *H. fuscipes* and *H. globosus*, the two species which are present in the Cayuga Lake basin. As the name *globosus* suggests, this member is strikingly globular in form, while *fuscipes* is much flatter and more elongate. Both are almost entirely black in color but the reddish brown legs of *fuscipes* are characteristic of that species. They are not very often taken together, although they have been recorded from similar habitats. *H. globosus* seems to prefer the banks of rapidly flowing streams or spring-fed pools, filled with leaves or vegetation, while *fuscipes* abounds more often in stagnant waters. However, where the leaf-filled pools tend to become stagnant both species usually occur.

Only the life history of the holarctic species, *fuscipes*, has been worked out but many authors have written about it. Cussac, 1855, gave the first account of the egg-case and Schiödt, 1862, added the remaining stages. Miall, 1895, contributed an interesting account of its biology but Balfour-Browne, 1910, must be credited with the most comprehensive treatise on the species. As yet, a complete description of the pupa has not been presented.

The egg-cases of both species are the first of the family to be observed in the spring. The earliest record was April 16 for *H. fuscipes*. The egg-laying continues in full force until the cases of *Tropisternus* and various others begin to appear. Then a diminishing in the number of cases takes place. However, the cases may be taken all through the summer and the middle of August brings the greatest number again. This latter statement is practically true of *globosus* also. The cases of *fuscipes* are more frequently found away from the bank, attached to floating vegetation, while those of *globosus* are placed in moss or in mud at the shore-line and usually entirely concealed, except the cap end.

Hydrobius globosus Say

Plate XI

In contrast with *fuscipes*, *H. globosus* is uniformly abundant throughout the entire summer. Adults gathered in the spring were placed in an aquarium-terrarium. On April 16 several cases were observed buried in the mud away from the water-line and only the cap and flare were showing. To the casual observer this white silk would resemble mould.

The next day one of the specimens was seen working on an uncompleted egg-case. The cap had not been made and there were only nine or ten eggs within it. Upon being disturbed, the beetle stopped spinning but almost immediately recommenced. More eggs were being laid and this process was interrupted only when the beetle wished to apply the inner loose covering of silk. This process of adding the full complement of eggs required about half an hour and another half-hour was spent in sealing up the opening. It took over an hour to make the broad flare and nearly an additional hour adding silk here and there, apparently making sure the case was properly sealed. Not only did it complete this one case but another smaller case was soon formed next to it and the flares of both fastened together.

The number of eggs varies from thirteen to twenty-five but the average number is twenty. The young larvæ come out the cap end, breaking through rather than pushing off the cap. No attempt was made

to rear any of them but they were very cannibalistic, constantly attacking each other. About twenty-five were left for several days in the same jar and only one larva survived. Some fed readily on the *Cyclops* in the jar but they were too ravenous to be satisfied.

A number of larvæ, apparently full grown, were placed in terraria but they would not transform. They burrowed down, making galleries all through the earth, and even formed cells but never pupated. There they lived for several months without food. All stages were found throughout the summer and, in early spring, the partly grown larvæ were frequently taken under stones, leaves, or in moss. There they were, half in water and half out, lying in wait for their prey.

EGG-CASE, proper, nearly spherical and about 4 mm. in diameter. A flat, round cap closes the upper end of the case and it measures 2 mm. across. The flare, which is continuous with the cap, varies, but one half of it is usually quite broad while the other half is narrow.

NEWLY HATCHED LARVA.—Length, 4.5–5 mm.; width at the thorax, 0.7–0.8 mm. Whitish, with light, yellowish brown, chitinized areas. The integument is covered with small, fine, brown, setæ.

Head quadrangular, 0.6 mm. wide and 0.528 mm. along the mid-dorsal line; fronto-clypeal suture weakly indicated; frontal sutures irregular but converging gradually and uniting to form a short epicranial suture; frons shaped somewhat like an arrow-head; cervical sclerites present; gula reduced, pentagonal, rounded posteriorly; the gular sutures prominent and confluent; articulating maxillary piece distinct.

Labro-clypeus prominent, asymmetrical and with five distinct, acute teeth; the outer tooth on the left set apart from the other four teeth, which are equidistant; six setæ present, one on each side of each tooth. Lateral expansions of epistoma not exceeding the labro-clypeus, rounded and each with a row of setæ at the anterior margin.

Ocular areas in groups of six but rather indistinct. They are arranged more or less in a compact circle. The anterior three with their axes more longitudinal while the posterior three have their axes more horizontal and the last, or sixth, area is more remote than the others, which are nearly equidistant from each other.

Antennæ fairly short, not exceeding the mandibles; just about attaining the distal end of the palpifer; the first segment constricted slightly in the middle and about the same size as the second; the second segment swollen with a small, colorless, antennal appendage and several sense-cones at its externo-distal angle; a long, slender, interno-distal seta present; third segment very much smaller than the latter and provided apically with sense-cones, besides two long, slender setæ.

Mandibles symmetrical, prominent, stout, sharply pointed at their tips, and each with three well-defined inner teeth. The most distal tooth is the largest, the middle one a little smaller, and the proximal one considerably smaller. The molar area is smooth and rounded.

Maxillæ with joint-like palpifer; stipes stout, tapering slightly, with a row of five setæ on its inner surface; palpifer with a slender chitinous appendage, longer than the first segment of the palpus and bearing a terminal seta at its disto-medial

angle; a single inner seta near its base; palpi shorter, gradually tapering; the first segment narrower than the palpifer and only about one-fourth the length of the second segment; the third is a little shorter than the second and provided with terminal sense-cones.

Labium extending forward almost as far as the tips of the mandibles; the first segment of the palpus short; the second segment about four times as long but nearly the same width and bearing several terminal sense-cones; ligula prominent, slender and almost twice as long as the first palpal segment; palpiger quadrate with sides slightly rounded; two long setae in the membrane at the base of the ligula; mentum slightly wider than palpiger, longer than wide and constricted a little in the middle; its dorsal surface with numerous short spines towards the sides and in the middle; the submentum extremely transverse and joint-like.

Prothorax with sides rounded, about the same width as the head. Anterior and posterior margins of pronotum narrowly non-chitinized; sagittal line present, prosternum with two large sclerites in front of the coxae and contiguous along the median line. Meso- and metathorax the same width as the prothorax but about one-half as long; sclerites of meso- and metanotum fairly large and irregular; the former subtriangular and less irregular than the latter, which are transverse and each with a posterior T-shaped projection. Epi- and hypopleurites both rounded, bearing a seta surmounting a little tubercle. Mesothoracic spiracles each at the tip of a small tubercle. Two small, elongate, pro-mesotergal sclerites present. Sagittal line prominent.

Legs about as long as the thorax is wide; coxae transverse; femora nearly as long as the tibiae; tarsi shorter than the latter, claw-like and with two inner setae, one more proximal and shorter. The anterior coxae are closer together than the four posterior coxae, which are about the same distance apart.

Abdomen with eight distinct segments and very slightly narrowed caudally, ninth and tenth segments rudimentary. The first seven tergites similar and separated by a conspicuous intersegmental membrane; each of the former has three transverse folds (scutellar fold indistinct) while the latter has only one. The praescuta bear two, oval, chitinized patches, those on the first segment slightly larger than the others. A transverse row of four tubercles, each bearing a seta, present on the posterior folds of the scuta and each segment with the spiracles on little conical tubercles. Epi- and hypopleurites prominently lobed and intersegmental membranes with a single prominent lateral lobe. Sternites with folds corresponding to those of the tergites. The eighth tergite represents the superior valve of the stigmatic atrium and bears a large chitinous plate, a little broader than long and somewhat semicircular, being rounded in front. The caudal border of the superior valve is slightly chitinized, bears a few setae, and is indistinctly quadrilobed, the two middle lobes more prominent. Ninth tergite trilobed. The entire structure closely resembles that of *Cymbiodyta*.

FULL-GROWN LARVA.—Length, 15 mm.; width, 2.96 mm. Color brownish above and dirty white or gray below. Tubercles and lobes of body much more pronounced, as well as the small brown setae covering the integument. Head measures 0.86 mm. along the dorsal line and 1.08–1.2 mm. in width. First segment of antennae about twice as long as the second. Terminal segment of palpus noticeably shorter than penultimate. Prothorax with several, small, dark markings on the pronotum and slightly widened posteriorly. Meso- and metathorax gradually wider than the prothorax. The stem of the T-shaped projections of the mesonotal sclerites lost. Legs

not as long as thorax is wide. First six segments of the abdomen about the same width as each other and slightly wider than the mesothorax. The scutella are more distinct. Seventh to eighth segments narrowed caudally. Small round patches composed of tapering setæ are present on the folds as follows: six on the anterior scutal fold, the two inner ones almost contiguous; three on the posterior scutal fold; four on the scutellum; and four on the intersegmental membrane. The pleural lobes also bear groups of these setæ in addition to the brown setæ.

Hydrobius fuscipes Linnæus

Plate I, Figures 3 and 8

In the early spring *fuscipes* is very abundant but, as the season progresses, they are harder to locate. Many have been taken under lights at night and they take flight very readily. Thus their apparent absence from their normal habitat is doubtless accounted for. This absence is evidently only periodic, as they are sometimes quite abundant in the middle of July when the pools are becoming concentrated. Miall says that many pupæ of *fuscipes* are found during July and that the globular cell is formed one-half an inch below ground in mud or clay on the bank. He adds that the adults appear in August and soon lay their eggs.

No constant differences could be found between the larva of this species and *globosus*. *H. fuscipes* is often a little smaller but otherwise they are apparently identical. No specimens of full-grown larvæ are at hand, but I would not expect striking differences in them. The middle tooth of the labro-clypeus seems to be constantly truncate in the specimens of *fuscipes* which were examined, but I hesitate to consider this as a separation character.

Hydrobius tessellatus Ziegler

A full-grown larva of this species was taken, together with the adult, by Mr. E. A. Schwarz. It was found among some leaves which had caught in the tree-roots near the bank of a swiftly flowing stream. The larva closely resembles *globosus* and is quite tuberculate.

Hydrobius scabrosus Horn

All the stages, except the egg-case, are in the U. S. National Museum Collection. They were taken September, 1891, in débris in a stream at Bear Creek, Montana. The larva looks very much like a small *globosus* larva. It differs, however, in the teeth of the labro-clypeus. The full-grown specimen has only four distinct teeth, three to the right and a fourth set a little to the left of the three. The middle tooth of the

three, however, shows an indication of another tooth. The mandibles have three inner teeth but the most proximal tooth of each is very small. The cerci of the pupa are tapering, fleshy, and about equal to the seventh to ninth abdominal segments inclusive. The motory styli of the abdominal terga are four in number and each pleurite bears one.

HELOCOMBUS Horn

Only one species, *H. bifidus*, represents the genus over the entire world. In the field it is often confused with *Hydrobius fuscipes* and differs principally in its longer maxillary palpus, the last segment of which is shorter than the penultimate. It might be taken for *Philydrus cinctus*, a common associate, but the elytra of the latter is not striate.

Few specimens have been captured in the immediate vicinity of Ithaca and it is only by chance that one collects them. However, they proved to be rather plentiful during May in the pools bordering the Ringwood Road at the source of Cascadilla Creek. Their life is spent under leaves at the edge of the ponds. The life history is unknown but the stages are probably close to *Cymbiodyta*.

CYMBIODYTA Bedel

Superficially this genus is very close to *Philydrus* but is easily separated by the transverse mesosternal carina, in contrast with the longitudinal keel of the latter. The presence of only four segments in the middle and hind tarsi bears additional testimony of the validity of this genus. In New York we have four representatives of this group, namely, *C. fimbriata*, *C. blanchardi*, *C. lacustris*, and *C. rotunda*. Of these, the two former have been collected in the vicinity of Ithaca in fairly large numbers, while there is doubt as to the presence of the latter two, although one specimen¹ of *lacustris* (?) was reported in 1909 by Professor J. C. Bradley. The life history of none of the species has been worked out.

Both *C. blanchardi* and *C. fimbriata* are found in the same environment and are often taken together. The easiest method of collecting seems to be taking the débris, including leaves, sticks, and decaying matter which accumulates near the shore-line, and washing the beetles out by placing and shaking the trash in deeper water. The beetles, as with other Hydrophilidae, rise to the surface and can easily be picked up by the fore finger and placed in the collecting jar. Often they are so

¹The specimen is not at hand so I was not able to verify its determination as such.

abundant that they may be taken readily from dead leaves, where the cling to the under side, apparently avoiding the sunlight. They have been observed in both still and flowing water but seemed to be most frequent dwellers in the little pools formed by rain-water or springs. One record shows a specimen captured in moss which was under a small fall in a swiftly flowing stream, but this evidently is not its most common *habitat*.

The best collecting grounds encountered for these two species were located at the base of a steep hill where the rain-water and springs, which trickled down over the surface of a small plateau, had formed small pools. The plateau was composed of a sandy loam and covered with a mat of dead leaves, etc. It was here in the middle and latter part of July 1916, that all stages of *C. blanchardi* and *C. fimbriata* were observed. Miss Ruby B. Hughes reported to me the presence of larvæ, which climbed up her tent-trap,¹ in abundance. The larvæ proved, in due season, to be *C. fimbriata*, as well as *C. blanchardi*, and a thorough examination of the surrounding area disclosed eggs and pupæ in unusual abundance. The larvæ in all stages were found under the leaves and stones; the eggs, in the moss on the bank; and the pupæ, as well as the emerging adults, in the bank.

***Cymbiodyta fimbriata* Melsheimer**

Plate XII

The arrangement of the eggs laid in the aquaria by members of this genus was rather puzzling at first because of the fact that no case seemed to be completed. The eggs alone were deposited and covered by a loose spinning of silk, such as is found within an egg-case, but with no outer covering, which is characteristic of the family.

On March 24, 1915, *C. fimbriata* was noted ovipositing in the aquarium on the under side of a stone which was lying out of the water. The beetle seemed to be having difficulty and, supposing from its actions that it was drying up, I placed a drop of water in such a position that it would roll on to the eggs. This, however, caused the beetle to leave its position immediately and it failed to return to its interesting occupation. When spinning, the spinnerets are protruded far out and the silk, which seems to be coming from the tips of the organ, is applied somewhat as paint is by a brush. When the drying up began, as noted above, the

¹Miss R. B. Hughes was at that time taking a census of the population emerging from damp places by placing a tent-trap and examining the catch at intervals.

silk seemed to become more and more sticky, thereby making it apparently hard work for the beetle to extricate the spinnerets at the end of each application.

Not until several egg-masses were procured in the field was I assured that *C. fimbriata* is in the habit of laying egg-masses without the usual coverings. On April 28, 1915, at McLean, while collecting in leafy pools where *Hydrobius globosus*, *Paracymus subcupreus*, *Ancæna infuscata* and *Cymbiodyta fimbriata* abounded, I turned up a layer of leaves which were moist but not in the water and noted a mass of thirty eggs similar to those laid in my aquaria indoors. When these had hatched they proved to be the eggs of *C. fimbriata*. In none of my observations on egg-laying have I noted an egg-mass laid by a *Cymbiodyta* that had the usual complete covering; which seems to be conclusive evidence that this species does not add the outer protective layer.

C. fimbriata laid from fifteen to forty-three eggs, which hatched out in seven to nine days. It was interesting to note that, if eggs were not taken out of aquaria and isolated, they were usually destroyed by the adults, although I did not observe them in the act.

The larvæ are apparently not as cannibalistic as the larger members of the group and appear not to notice their brothers and sisters unless they accidentally bump into each other. However, one specimen was observed devouring a larva of *Philydrus* which was about the same size as itself. The length of life history in this genus is probably about two months. On May 19, 1915, two large larvæ, evidently hatched from the egg-cases found the latter part of March, were observed in the aquarium. About the middle of June they seemed fairly mature but died without pupating.

Although I have not determined the length of the pupal period in either of the two species, it is probably three or four days, as in *Philydrus*. Upon finding the larvæ in all instars on the flats above mentioned, I searched the bank to see if the pupæ of the beetle could not be located. The first day brought little reward except the egg-masses of *C. blanchardi*. However, on the second day, fortune favored me and several feet from the water in slightly moist loam and an inch or less under the moss, a veritable array of pupæ, including more especially those of *C. blanchardi*, *C. fimbriata* (few), *Dascyllidæ* and *Dytiscidæ*, was found. All stages, except the egg stage, were present in the cells and so, by digging carefully and saving the pupal and larval skins, the necessary connecting links in their life history were easily obtained.

The adults of *C. fimbriata* upon emerging are light brown below; the thorax is light brown; their head is darker brown; the second pair of wings are gray; the first pair are white; and the eyes quite dark brown. Until fully colored, about two days, the adults seemed to remain in their cells, as many were noted as being very dark when removed from their underground home.

On April 11, a number of adults of *C. fimbriata* were dug out from the bank of a pool about five or six feet from the shore-line. This tends to show where the beetles spend their winter days.

EGGS.—There seems to be no special arrangement of the eggs except that they are usually placed like logs in a pile and covered sparsely with fine white silk, through which the eggs may be seen.

NEWLY HATCHED LARVA.—Length, 3 mm.; width, 0.4 mm. Whitish. Head and mandibles light yellow; sclerites of thorax and abdomen light brown (mesocerci darker); integument dotted with minute spines, which are more abundant on the top of the folds than in the furrows.

Head square, elevated slightly; fronto-clypeal sutures weakly indicated; frons limited by the frontal sutures, gradually narrowed towards the median line, semi-circular behind; epicranial suture very short, almost absent; gula reduced with its sutures fairly prominent and confluent; two, small, horizontal, elongate, cervical sclerites present.

Labro-clypeus irregularly toothed, possessing usually seven teeth (the most lateral tooth on each side indistinct), some of which tend to be toothed again, and with four short spines, a little longer than the teeth, regularly placed, arising dorsally between the bases of these teeth and projecting forward. The lateral expansions are similar to each other, with anterior margin straight and slightly inclined laterally. Epipharynx spinous.

Ocular areas in groups of six but rather indistinct. They are arranged more or less in a circle. The anterior three have their axes more horizontal and the last, or sixth, area is more remote than the others, which are nearly equidistant from each other.

Antennæ fairly short, not attaining the tips of mandibles but exceeding the distal inner tooth; first segment equal in length and width to the second; second segment not noticeably swollen in the middle and bearing a small colorless, two-segmented, finger-like antennal appendage, the basal segment small, in addition to the sense-cones, and a single, small, slender appendage at the latter's base and at the inner anterior angle; third segment a little longer than the appendage of the second segment, which is three times as long and wide as the former, and bearing at its extremity three long setæ and several sense-cones.

Mandibles nearly symmetrical, fairly prominent and stout, sharply pointed at their tips, and each bearing two inner teeth, the basal one smaller; the left basal tooth seems to be slightly smaller than the right basal tooth; inner surface of anterior piece and anterior tooth serrate; molar area not serrate.

Maxillæ with joint-like palpifer; stipes large, swollen, narrowed slightly towards the apex, longer than the palpifer and palpus together, and its inner surface provided with a row of five stout setæ and several more slender setæ near the externo-distal angle; palpifer small, a little wider than long, bearing a single, stout, inner, lateral seta,

near its base, and an inner rudimentary lobe, possessing apical setæ; first segment of palpus the same length as the rudimentary lobe of the palpifer and a little more than half the second, while the third is not quite as long as the first two together but more slender and more cylindrical; each bears a few slender setæ, the terminal segment possessing a group of sense-cones at its extremity. Articulating maxillary piece well developed.

Labium extending forward almost as far as the tips of the mandibles; submentum very small; mentum somewhat cordiform; palpiger dome-shaped, four-fifths the mentum in length, bearing several prominent setæ dorsally; labial palpus with first segment short, second segment about three times as long and bearing sense-cones at its tip; ligula present and slightly exceeding the first segment of palpus in length.

Prothorax with sides slightly rounded, of same width as head. Anterior third of pronotum non-chitinized, sagittal line present, prosternum with two fairly large sclerites in front of the coxæ. Meso- and metathorax a little narrower and shorter than the prothorax; sclerites of mesonotum and metanotum fairly large, the former subtriangular and the latter elongate; two elongate sclerites are present in the promesotergal conjunctivum; sagittal line prominent. A spiracle on a small tubercle at each antero-lateral angle of the mesothorax.

Legs fairly long, slightly longer than thorax is wide; coxæ transverse, grooved laterally to receive the femora; femora longer than the tibiæ; tarsi well developed, claw-like, about as long as the tibiæ and bearing two inner setæ. The anterior coxæ are closer together than the four posterior coxæ, which are about the same distance apart.

Abdomen with eight prominent segments and very slightly narrowed caudally, ninth and tenth rudimentary. The first seven tergites similar and separated by a conspicuous intersegmental membrane; each of the former has three transverse folds while the latter has only one. The first tergite bears two transverse chitinized patches on its præscutum. Lateral tubercles are not clearly defined but there are apparently two larger ones on the segment and two smaller more pointed ones on the membrane following. The sternites are not chitinous and have folds corresponding to those of the tergites. The eighth tergite represents the superior valve of the stigmatic atrium and bears a large chitinous plate, which is a little broader than long. The caudal border of the superior valve is chitinized, bears a few setæ, and is slightly bilobed.¹ Procercus one-segmented, subconical, with a chitinous plate on the inside and a group of three setæ arising dorsally from tubercles on their apical half. Mesocercus two-segmented and chitinous; the first segment dome-shaped, bearing a central dorsal seta as well as a ventral seta; the second segment very small, papilliform and bearing a terminal seta (0.4 mm. long); between these two segments there are several sense-cones in the membrane. The ventral valve, or ninth tergite, is trilobed posteriorly and the lateral lobes possess chitinous areas from which arise two setæ mounted on tubercles. The acrocerci² are evidently attached to the under side of these lobes and each bears a terminal seta. The median lobe is large and somewhat cordiform; its dorsal surface covered, except for a narrow border, with a chitinous plate. Near the caudal margin are four setæ, the outer two of which are in line with each other and a little anterior the median two.

¹The outer lobes, which are present in many of the Hydrobiina, are indistinct here.

²A question arises as to whether the acrocerci are the dorsal tubercles and setæ or the ventral. It is difficult to determine; but, from position as described by d'Orchymont, I have considered them as ventral.

FULL-GROWN LARVA.—Length, 7–10 mm. ; width, 1.25–1.8 mm. Orange-colored and, when it is not too dirty, has a peppery appearance due to the dark coloration of the integument at the base of the spines which cover the body. A striking transverse row of dark spots is noted in some larvæ on the tops of the abdominal folds. Head, dorsally, is 0.77 mm. long and 0.64–0.9 mm. wide. Spines of labro-clypeus mostly lost and teeth present a scalloped appearance. Anterior inner teeth of mandibles without serration.

PUPA.—Length, 7 mm.; width at its thorax, 3.2 mm. Whitish. Head smooth and bears two supraorbital styli on each side. Pronotum smooth, its anterior margin somewhat trilobed and its posterior margin straight, slightly indented just in front of the base of the elytra. The styli are arranged as follows: ten on the rounded lateral and anterior margins, two of which are on the middle lobe; eight on the posterior margin, counting the two corner ones; two on the middle lobe just posterior and slightly lateral of the two anterior styli; and a transverse row of four in the middle, the outer two a little anterior to the inner two. Mesonotum and metanotum with a transverse row of two styli. Inner spur of metatibia fairly prominent. Tarsi not ending in a spine but blunt and tibiae not spinous on the outer side. Metathoracic pterothecæ visible from above. First abdominal tergite with a transverse row of four styli; second to seventh abdominal tergites, inclusive, with a transverse row of six styli, the outer one on each side arising from tubercles; second to seventh pleurites each with a stylus; eighth tergite semicircular, the rounded posterior margin bearing two styli; ninth segment with a pair of cerci, a little longer than the eighth and ninth segments together (0.72 mm.), extending caudally and very slightly diverging; ninth sternite with prominent acute externo-caudal angles, a pair of appendages arise from between the eighth and ninth sternites and extend caudad on either side of the median line as far as the base of the cerci and closely appressed. Spiracles fairly prominent and slightly raised.

***Cymbiodyta blanchardi* Horn**

The different stages of this species seem to be practically identical with *C. fimbriata* except that they are smaller in size. The larva possesses a pair of small, very indistinct, oval patches on the second to seventh abdominal tergites, which were not present on the larvæ of *C. fimbriata*.

HELOCHARES Mulsant

The only eastern species, *H. maculicollis*, has not been recorded from our fauna and is not to be expected. It is a more southern species and reaches northward along the Mississippi River and its tributaries only as far as Ohio, Illinois, and Missouri. According to Blatchley, 1910, it occurs very rarely in Indiana (Lawrence and Dubois Counties).

Formerly this genus was united with *Philydrus* and it closely approaches it. *Helochares*, however, may be easily distinguished in the field by the punctures of the elytra, which are arranged in rows. In general form, it is more like *Helocombus*, but this genus possesses longer maxillary palpi and its elytra are distinctly striate.

Cussac, 1852, described the immature stages but his work was not very carefully done. The full-grown larva was figured as well as the pupa. The latter, however, was destroyed before the drawing was finished, with the result that the caudal end was not accurately completed. D'Orchymont, 1913, acting on Ganglbauer's suggestion for a more accurate description of the European species, *H. lividus*, gave an excellent description of the larva and supplemented it with figures.

***Helochares maculicollis* Mulsant**

Plate XIII

I am deeply indebted to Mr. F. E. Wintersteiner for the opportunity of rearing *H. maculicollis*. On April 12, 1916, I received ten living adults which he had forwarded to me from Richmond, Virginia. They were apparently in good condition, although a number of mites were attached to them on the under side. The specimens had been collected at the edge of leaf-filled pools a few days previous to their shipment.

When placed in the rearing jar, they immediately became submerged and remained on the under side of some stones or burrowed down in the mud. Although on sunny warm days they would be seen swimming about the jar, yet most of their time was spent in hiding. Because of this fact, it was difficult to observe whether or not the females carried any cases as they were reported to do.

On June 4 the container was flooded and soon a number of young larvæ were noted floating on the surface and crawling around the edge of the glass. Later in the day two females were seen swimming at the surface of the water, right side up, each with an egg-case slightly protruding caudally.

The egg-case was attached by two strands to the hind femora and not free as Schiödte describes it in *lividus*. The beetles could swim with little incumbrance. Both cases hatched out two days later and forty-six and forty-two larvæ appeared from the respective cases. Other cases were observed during the first week in July and a single case as late as September 24. The latter case hatched on the 29th. The larvæ

very closely resemble those of *Philydrus* and are very voracious. They do not hesitate to devour each other and apparently flourish on *Cypriodopsis* and *Tubifex*.

Little attention has been paid to the growth of the larvæ but on August 31 of the same year several full-grown larvæ were placed in the terrarium. One of these formed a cell and transformed on September 4. The cell was firmly made and was apparently larger than need be, measuring 7.5 mm. long, 7 mm. wide, and 4.5 mm. high.

EGG-CASE.—Nearly semicircular; follows the contour of the abdomen but slightly exceeds it. It measures 2.16 mm. long and is 2.88 mm. wide at the anterior margin. The two strands which attach the case to the inner margin of the posterior femora are short and flared at the point of attachment. All the eggs are pointed inwardly and their contour is visible through the silken case. The silk on the under side of the case is more tightly woven than that on the dorsal side.

NEWLY HATCHED LARVA.—Length, 2.28 mm.; width at the thorax, 0.342 mm. Whitish, except the brownish chitinized areas; integument dotted with minute setæ.

Head quadrangular, slightly elevated; fronto-clypeal suture weakly indicated except at the sides; frons gradually constricted towards the middle, semicircular behind; frontal sutures uniting to form a short epicranial suture; gula reduced, pentagonal, somewhat semicircular behind; gular sutures prominent and confluent for a long distance; two small, horizontal cervical sclerites present.

Labro-clypeus asymmetrical, with six distinct teeth, all equidistant from each other except the two on the left which are set slightly apart from the other four. Six setæ are present, one on each side of each tooth except between the fourth and fifth from the right. Lateral expansions of the epistoma prominent, nearly similar and with obtuse angles, but not exceeding the labro-clypeus. Epipharynx spinous.

Ocular areas in groups of six and indistinct; arranged somewhat in a circle; the front five placed at regular intervals, while the sixth is a little more distant with its axis nearly horizontal.

Antennæ fairly short, not quite attaining the tip of the mandible nor distal end of the stipes; first segment not quite as long as the second segment, slightly constricted; second segment swollen, about the same width as the first and bearing at its disto-external angle a slender, finger-like antennal appendage as well as a spine-like seta; third segment small, less than one-fourth the length of the second but longer than the antennal appendage and possessing two long slender setæ and several shorter ones.

Mandibles stout, nearly symmetrical, their tips sharply pointed and each with two inner teeth, the proximal tooth being smaller than the distal one; the proximal tooth of the left mandible smaller than that of the right; the anterior pieces and inner teeth indistinctly toothed on their inner surfaces. Molar areas smooth and rounded.

Maxillæ with joint-like palpifer; stipes stout, swollen, not noticeably narrowed towards the apex, about two-fifths longer than the palpus and palpifer together, its inner surface with a row of five stout setæ, and two slender setæ near the externo-distal angle; palpifer short, transverse, and bearing an inner rudimentary lobe, possessing two apical setæ; palpus slightly tapering; the first segment shorter than the palpifer and less than one-fourth as long as the second palpal segment; the third segment slightly shorter than the second and with distal sense-cones.

Labium not attaining the distal end of the stipes; submentum extremely transverse, short, joint-like; mentum somewhat cordiform, its upper surface with numerous short spines and a seta in each externo-frontal angle; palpiger shorter than submentum and with sides rounded; first segment of palpus short; second segment about three times as long and possessing several slender apical setae; ligula well developed, slender and almost twice the first palpal segment in length.

Prothorax with sides slightly rounded, of the same width as the head; pronotum well chitinized except at anterior and posterior margins; sagittal line present and continuing throughout the thorax; prosternum with two large sclerites in front of the coxae touching along the median line. Meso- and metathorax slightly wider than prothorax but about one-half as short; mesonotum with fairly well-developed sclerites divided in front by a horizontal suture and with four slightly chitinized square areas at its posterior margin. Pro-mesotergal and meso-metatergal conjunctiva with two very narrow sclerites. Sclerites of metanotum very irregular, each with a widely separated posterior projection. Episterna and epipleura are cushion-like lobes.

Legs fairly long, about twice as long as the thorax is wide; coxae transverse, a little longer than the femora; tibiae slightly shorter than the latter but much longer than the well-developed claw-like tarsi, which bear two inner setae set side by side. The anterior coxae a little, the middle more, and the posterior widely separated.

Abdomen with eight distinct segments and very slightly narrowed posteriorly; ninth and tenth segments rudimentary. The first seven tergites similar and separated by a conspicuous intersegmental membrane; each of the former has three transverse folds, while the latter has only two. The first tergite bears two pairs of small, chitinized patches, the anterior very small and usually covered by the metathorax. Episternites and epipleurites similar to the thoracic ones and are cushion-like lobes. Lateral lobes of intersegmental membranes single and not double as in *Philydrus*. The second fold of each of the first seven segments bears a transverse row of four inconspicuous tubercles, the inner pair more prominent with a small chitinous ring at its base. The tubercles each bear a colorless seta. The sternites have folds corresponding to those of the tergites but have no chitinized areas. The eighth tergite represents the superior valve of the stigmatic atrium and bears a large plate which is wider than long. The posterior margin of the latter is nearly straight, its sides are rounded and its anterior margin only slightly emarginate. The posterior margin of the superior valve is four-lobed, each lobe with a seta. The atrium closely resembles that of *Cymbiodyta*.

FULL-GROWN LARVA.—Length, 8 mm.; width at the mesothorax, 1.27 mm. Gray colored or dirty white except chestnut-brown chitinized areas. Head, dorsally, 0.6 mm. long and 0.69 mm. wide. Labro-clypeus is more oblique. The first segment of the antennae has become more elongate and now is longer than the second segment, the antennal lobe is slightly shorter and less prominent. Mandibles are very blunt and have lost their serrations. Mentum with the seta in each externo-frontal angle prominent as well as each medio-lateral one. Prothorax enlarged slightly posteriorly. Body increases in width gradually as far as the second abdominal segment and then decreases.

PUPA.—Length, 5.2 mm.; width at its thorax, 2.16 mm. Whitish. Head smooth and bears two supraorbital styli on each side.

Pronotum smooth, its anterior and posterior margins straight, the latter very slightly emarginate in the middle. The styli are arranged as follows: ten at the lateral and anterior margins, two of which are at the middle of the anterior margins;

eight at the posterior margin, counting the two corner ones; two just posterior and slightly lateral of the two middle styli of the anterior margin; a transverse row of four in the middle, the outer two a little anterior the inner pair; a few other inconspicuous styli are present.

Mesonotum and metanotum with a transverse row of two styli. Inner spur of metatibia not very prominent. All tarsi not ending in a spine but blunt and tibiæ not spinous on the outer side; first to seventh abdominal tergites inclusive with a transverse row of six styli; second to seventh pleurites each with a stylus; eighth tergite semicircular, the posterior rounded margin bearing two styli; ninth segment with a pair of tapering, fleshy cerci, longer than the ninth tergite (0.62 mm.) extending caudally and diverging slightly. Externo-caudal angles of ninth sternite obtuse and not very prominent. A pair of appendages arise from between the eighth and ninth sternites and extend caudally on either side of the median line to the base of the cerci and closely appressed to the ninth segment. Spiracles oval, prominent, second to sixth visible.

***Holochares normatus* LeConte**

Zaitzev, 1908, placed this species under *Chasmogenus* but questions it. The egg-case, as well as the larva, closely resembles *H. maculicollis* and it doubtless belongs under this genus.

***PHILYDRUS*¹ Solier**

In our fauna there are six members of this group and, although they are apparently close in general structure, yet coloration, size, and form play such an important part in their separation that they are easily determined after one has had a brief introduction to the systematic study of them. The most easily confused member is doubtlessly *P. perplexus*, which may be easily placed as *Cymbiodyta fimbriata* unless the genus is first assured. In size the species range from *P. ochraceus* (the smallest), *P. nebulosus*, *P. perplexus*, *P. hamiltoni*, and *P. cinctus* to *P. consors* (the largest). The first two species named are very abundant near Ithaca while the latter three are comparatively rare, although one mud-pocket yielded about a dozen specimens of *P. consors* in company with a larger number of *Cymbiodyta fimbriata* when the writer was collecting in late June.

The life history of this genus has been studied only in Europe, where Schiödt reared *P. testaceus* Fabr. and figured² the stages in his well-known work. The writer has been able to compare this life history with that of some American forms which he has reared.

¹Zaitzev, in his 'Catalogue des Coléoptères aquatiques familles des Hydrophilidæ' gives *Enochrus* as the valid name, claiming that *Philydrus* is preoccupied, but the author feels convinced that *Philydrus* should stand. *Philydrus* was originally used without the "h."

²The figures by Schiödt are not entirely accurate. The labro-clypeus should be oblique and the left mandible was evidently incorrectly drawn.

The common habitat of all the species seems to be in small pools, either at the water's edge in the mud or in the *Spirogyra* farther out. *P. nebulosus* may be taken at almost all times of the year, depending in the winter upon warm spells. October 17 of one year proved to be the most profitable day encountered for the procuring of the adults of this species, when as many as fifty were taken from the roots of the vegetation bordering the shores of Dwyer's Pond.

The eggs, which vary in number and size in the different species, are usually enclosed in an outer covering of silk or cocoon in addition to the usual inner layer and are particularly characterized by the ribbon-like filament, which only the genus *Hydrobius* approaches. The cocoons are found attached to all kinds of objects but usually at the surface of the water, more frequently to blades of grass or *Spirogyra*, with its ribbon stretched out over the surface. They are laid most abundantly during May but are found from April to August in the field. Indoors they are apt to be laid any month in the year. Ten egg-cases were made by a single specimen of *Philydrus nebulosus* during February and some of them were placed below the surface of the water. The time required for hatching is from six to nine days.

The larvæ may be procured during the summer months by strenuously washing the banks of pools where the egg-cases or adults are found. They seem to burrow in the mud near the water's edge, while some repose on the under side of stones as far from the water as it is moist. In their method of walking they resemble very closely the eruciform type, as their motion is rhythmic. The true legs move first, the inconspicuous prolegs next, and finally the end of the abdomen is used. The larval period lasts about two months.

The pupal stage is quite short, taking up three or four days. This stage was observed indoors either in the aquarium where it was formed or else by taking the mature larva and placing it in a jar with moist earth, where it formed a cell below the surface in the usual manner or pupated on top of the ground. On July 20, 1916, many pupæ of *P. nebulosus* and *P. perplexus* were found in cells underneath stones or in the moist bank. The pools at this time of the year were gradually drying up and naturally possessed a concentrated array of beetles.

The progress of coloring in the adult, after emergence, was observed in *P. nebulosus*. At first the head, thorax, and elytra are very dirty white, nearly brown, and the appendages of the head nearly white, while the legs are tinged a little with brown. The eyes soon get black and the whole body darkens gradually, the thorax getting its color much more slowly than the elytra.

Philydrus perplexus LeConte

Plate XIV, Figures 1 to 10

EGG-CASE, without its ribbon, shaped very much like the terminal joint of one's finger. The top of the case is slightly concave, while the under side conforms with the object to which it is fastened. The case proper is 1.8 mm. high and 1.56 mm. across the top, where the greatest width is found. The filament is broader than the diameter of the cap and, although varying in the different cases, is usually about 3.6 mm. in length. The round cap, covering the top of the egg-case proper, is continuous with the inner layer of the ribbon.

NEWLY HATCHED LARVA.—Length, 2.52 mm.; width, 0.39 mm. Whitish, except brownish chitinated portions; integument dotted with minute setæ.

Head quadrangular, elevated slightly; fronto-clypeal suture weakly indicated, more prominent at the sides; frons somewhat campanulate; epicranial suture very short; gula reduced and pentagonal, the antero-lateral sides about one-third the postero-lateral in length; gular sutures prominent and confluent; two small, horizontal, elongate cervical sclerites present.

Labro-clypeus possesses at the extreme right a prominent acute tooth and a row of five to six setæ; the tooth on the right seems to vary quite a little, in some cases being apparently single, in others double and in some tending to be tridentate. Just below there appears to be a flap which is irregularly serrate, and has a fairly prominent tooth¹ at the extreme left. Lateral expansions of epistoma prominent, unequal, acute and slightly exceeding the labro-clypeus. Epipharynx spinous.

Ocular areas in groups of six and indistinct; arranged somewhat in a circle; the first five placed at regular intervals while the sixth is a little more distant with its axis nearly horizontal.

Antennæ fairly short, not attaining the mandibles but exceeding the distal inner tooth; first segment equal to the second in width and nearly the same length; second segment not noticeably swollen in the middle and bearing a small, colorless, finger-like antennal appendage, in addition to the sense-cones at the latter's base; third segment nearly twice as long as the appendage of the second segment, which is three times as long and wide as the former, and bearing at its extremity several sense-cones and long setæ.

Mandibles asymmetrical, fairly prominent, sharply pointed at their tips and with the inner surface of the anterior piece slightly serrate; the left mandible with a single anterior tooth while the right one possesses two; both of the anterior teeth serrate on their inner surface, those of the left often very indistinct; molar areas smooth.

Maxillæ with joint-like palpifer; stipes large, swollen, not noticeably narrowed toward the apex, longer than the palpifer and palpus together, its inner surface provided with a row of five stout setæ, and several slender setæ near the externo-distal angle; palpifer small, the length five-eighths the width, bearing a single stout, inner, lateral seta near its base and a rudimentary lobe possessing apical setæ; palpus borne by the palpifer, three-segmented; its first segment equal to the rudimentary lobe of the palpifer in length and a little more than one-half the second, while the third is not

¹This tooth may be a part of the labrum proper but in most specimens seems to be in line with the serrate flap.

quite as long as the first two together but slightly more slender and tapering; each bears a few slender setæ, the terminal segment being highly sensory and provided with a group of sense-cones at its extremity. Articulating maxillary piece well developed.

Labium just exceeding the palpifer of the maxillæ; submentum small; mentum somewhat cordiform; palpiger dome-shaped, two-thirds the mentum in length, bearing a longitudinal row of three dorsal setæ on each side of the median line; labial palpus with first segment short, second segment less than three times as long and bearing sense-cones at its tip and a number of setæ at its base; ligula present and a little longer than the first segment of the palpus.

Prothorax with sides slightly rounded, of the same width as the head; anterior and posterior of pronotum non-chitinized; sagittal line present; prosternum with two fairly large sclerites in front of the coxæ touching along the median line; meso- and metathorax shorter than the prothorax, and the metathorax narrower than either thoracic segment; sclerites of mesonotum and metanotum fairly large, the former crescent-shaped as a whole, and the latter irregular; two inconspicuous, narrow sclerites are present in the pro-mesotergal conjunctivum; sagittal line prominent. Mesothoracic spiracles mounted on a small tubercle in each antero-lateral angle.

Legs fairly long, a little longer than the thorax is wide; coxæ transverse, grooved laterally to receive the femora; femora a little longer than the tibiæ; tarsi well developed, claw-like, about as long as the latter and bearing two inner setæ; the two anterior coxæ are closer together than the four posterior coxæ, which are about the same distance apart.

Abdomen with eight segments distinct and very slightly narrowed caudally, ninth and tenth segments rudimentary. The first seven tergites similar and separated by a conspicuous intersegmental membrane; each of the former has three transverse folds while the latter has only two. The first tergite bears a pair of subrectangular chitinized patches on its præscutum, while there is a pair of small oval, chitinized patches on the præscuta of the next six segments. Lateral tubercles are not clearly defined but there is apparently one large one on the segment and two smaller more pointed ones on the membrane following. On the second fold of each of the seven segments, a transverse row of four tubercles, each bearing a seta, may be seen. A pair of very inconspicuous spiracles present on each of the first seven segments. The sternites are not chitinous and have folds corresponding with those of the tergites. The third to the seventh each possess a pair of prominent tubercles which resemble prolegs and are furnished with a group of recurved spines on their ventral surface. The eighth tergite represents the superior valve of the stigmatic atrium. As the larvæ of this genus belong to the same type of pseudo-metapneustic larvæ as *Cymbiodyta*, a redescription of the atrium seems unnecessary.

FULL-GROWN LARVA.—Length, 6–8 mm.; width at the mesothorax, 1.80 mm. Gray or dirty white and, when not too dirty, somewhat peppery, but not so noticeably as in *Cymbiodyta*. A transverse row of dark spots is noted on the tops of the abdominal folds in some larvæ, especially those which have just molted.

Head, dorsally, 0.768 mm. wide and 0.624 mm. long. Serrate flap of labrum mostly lost, except tooth at right, and frontal angles blunt. Appendage of second segment of antennæ much smaller in comparison with the third segment. Serrations of the anterior teeth of the mandibles lost and those of the inner surface of the anterior piece very indistinct or lost. The first segment of maxillary palpus about one-half the second. A row of four stout dorso-lateral setæ on each side of the mentum and a

strong dorsal seta on either side of the median line, slightly anterior in position; the seta at the base of the labial palpus stout and fairly prominent and those at the base of the second segment slender.

PUPA.—Length, 5.13 mm.; width at its thorax, 2.22 mm. Entirely whitish, except eyes. Head smooth and bears two supraorbital styli on each side, the anterior styli more lateral than in *Cymbiodyta*, in which they are set nearer the median line than the posterior styli; an inconspicuous tubercle on each side of the median line near the vertical margin.

Pronotum smooth, its anterior margin somewhat trilobed and its posterior margin straight, slightly indented just in front of the base of the elytra. The styli are arranged as follows: ten on the lateral and anterior margins, two of which are on the middle lobe; eight on the posterior margin counting the two corner ones; two on the middle lobe just posterior and slightly lateral of the two anterior styli (these four styli are more in a transverse line than in *Cymbiodyta*) and a transverse row of four in the middle, the outer two a very little anterior the inner pairs. Mesonotum and metanotum with a transverse row of two styli. Inner spur of metatibia fairly prominent, an outer adjacent spur less prominent. Tarsi not ending in a spine but blunt and tibiae not noticeably spinous on the outer side, although the meso- and metatibiae have slight indications of spines. First abdominal tergite with a transverse row of four styli; second to seventh tergites inclusive, with a transverse row of six styli, the outer one on each side arising from a tubercle; second to seventh pleurites with a stylus; eighth tergite semicircular, the rounded posterior margin bearing two styli; ninth segment with a pair of tapering, fleshy cerci, a little longer than the sixth to ninth tergites together (1.2 mm.), extending caudad and very slightly diverging. Ninth sternite with prominent, acute, externo-caudal angles. A pair of appendages arise from between the eighth and ninth sternites and extend caudad on either side of the median line to the base of the cerci and closely appressed to the ninth segment.

***Philydrus nebulosus* Say**

Plate I, Figure 9

This species is very close to *P. perplexus* in its early stages and the egg-cases have no distinctive characteristics for their separation. From thirteen egg-cases, an average of 19 larvæ were obtained with 24 and 11 as the extremes. Eggs, laid on March 16, hatched on the 25th. They seemed to feed readily on the entomostracans, Chironomidæ, *Tubifex*, etc., in the aquarium, and the first molt was noted in eight days. I failed to see the second molt but on June 3 pupæ were observed on *Cladophora*, which had pushed just above the surface of the water. The newly hatched larvæ measured 2.256 mm. in length by 0.312 mm. The inner surfaces of the anterior pieces and anterior teeth of the mandibles and flap of labrum much more prominently toothed than in *perplexus*. These latter serrations seem to keep prominent in the more mature larvæ, although most of the fully grown larvæ are hardly distinguishable from *P. perplexus*.

The pupa is identical with that of *perplexus*, except that it is generally smaller. Length, 4.5 mm.; width, 1.6 mm.

***Philydrus ochraceus* Melsheimer**

Plate XIV, Figure 11

As this is our smallest *Philydrus*, the stages are smaller throughout. The egg-case, which is characteristic of this genus, is much more flattened than in the other species and the ribbon seems to be correspondingly broader. The length of the case proper is 1.32 mm., its width about the same, while the filament is twice as long, or 2.65 mm., in the specimens at hand. An average of twelve eggs hatched from each case.

NEWLY HATCHED LARVA.—Length, 1.97 mm.; width 0.288 mm. Chitinized parts light yellow; and reddish eyes are distinct. Inner surface of the anterior piece of each mandible distinctly serrate; the right anterior tooth dentate but the left anterior tooth and the right posterior tooth simple.

***Philydrus cinctus* Say**

Although I question whether it is the customary habit of this species to omit the usual outer covering, yet such was the condition found in one of the indoor aquaria. On June 4, 1915, a female laid a mass of thirty eggs, perpendicular to a stone under some *Cladophora* and with only the loose inner spinning of silk to cover it. Unfortunately, the eggs did not hatch. The full-grown larva, measuring 7.9 mm., was, however, captured. It had no serrations on the mandibles and the labro-clypeus possessed a single tooth at the extreme right and left. Serrate flap with four inconspicuous teeth. Pupation occurred on July 20 and the adult emerging on the 23rd was entirely light brown.

***Philydrus hamiltoni* Horn**

An adult female taken on May 11, 1916, deposited an egg-case on a moneywort leaf in the aquarium the 15th, and thirty larvæ hatched out on May 20 and 21. On the same day that the adult was collected, an egg-case was taken in Vanishing Brook, where it was attached to a blade of grass at the edge of the water. The egg-case proper is 3.4 mm. wide at the middle and 2.3 mm. high. The filament, which spread out over the surface of the leaf, measured 2.3 mm. in width and 6.8 mm. in length. It is of about the same breadth throughout and in this respect is more like *ochraceus* than *nebulosus* or *perplexus*.

NEWLY HATCHED LARVA.—Length, 2.66 mm.; width, 0.39 mm. Chitinized parts mostly brownish; the anterior of the head, however, except the palpus of the maxilla, light yellowish. Inner surface of the anterior piece of each mandible serrate. The right distal inner tooth serrate but the distal left and the right proximal inner teeth are simple. The serrate flap of the labrum is fairly conspicuous and with a very prominent tooth at the left.

***Ancæna* Thomson (*ex parte Cryniphilus*¹)**

There is hardly a stream or pool in the vicinity of Ithaca that will not yield the only representative of this genus which frequents our waters, *Ancæna infuscata*. The specific name is well applied but close examination is necessary to be absolutely positive that it is not the closely related *Paracymus subcupreus*. The most ready character for their separation lies in the nature of the hind femur which in *infuscata* is densely punctulate and pubescent, except near the tip; while in *subcupreus* it is smooth, finely strigose, and not pubescent but with a few scattered punctures.

Although very often taken together, yet some collecting grounds will show one or the other of these species to be in predominance, *A. infuscata* being the more numerous as a rule. The adults are particularly abundant during certain seasons. The spring season collecting brings the richest harvest and hundreds of them may be taken in single clumps of grass, the roots of which are submerged in the waters of little pools or streams during the week following the spring flood. They rarely seek the sunlight, at least in cool or cloudy weather, but hide beneath the blades of grass, leaves, or débris at the shore-line. One day, however, a group of them was noted dotting the upper surface of some submerged stones; they were apparently basking in the sunlight and very much resembled small scale insects. When searching for their place of hibernation, several were taken in April a few feet from the water under stones and pebbles.

D'Orchymont described the larva of *Ancæna limbata*. This species closely resembles *Paracymus subcupreus* but differs considerably from *A. infuscata*.

***Ancæna infuscata* Motschulsky**

Plate XV

The egg-cases are similar to those formed by *Laccobius*, from which they are separated with difficulty. My notes for the season of egg-laying give only the month of May. The number of eggs, enclosed in the case,

¹This is the original spelling of the genus. Later authors incorrectly used *Cryniphilus*.

varied from five to eight, and ten days were required for eggs laid in the aquaria on May 12 to hatch. It is possible to obtain larvæ during nearly the whole year, if the aquarium is well stocked with adults. Records show them to be present from April to October, inclusive, besides during February. A number of fairly well-grown larvæ were found under a stick in a moist situation on May 28. As pupæ were observed during the middle of July, the larval period is probably of about two months' duration.

EGG-CASES.—Case, without its filament, nearly round and varies in size, as does the filament. The case proper averages 1.13 mm. in width and 1.08 mm. in length; and the filament, 0.44 mm. in width at its base and 3.47 mm. in length. The top of the egg-case tends to be slightly flat and the cap is continuous with the filament, forming a slight cavity at the base of the filament, which tapers slightly towards its tip and is flat and ribbon-like.

NEWLY HATCHED LARVA.—Length, 1.67–1.93 mm.; width, 0.296 mm. Whitish, except chitinized portions which are yellowish; integument, including thoracic sclerites, dotted with minute setæ which arise from microscopic tubercles.

Head quadrangular, very slightly elevated; fronto-clypeal suture weakly indicated, more prominent at the sides; frons somewhat campanulate, its rounded posterior end attaining the caudal margin of the head so that there is no epicranial suture and the postfronto-vertical sclerites do not meet; gula pentagonal, and the gular sutures prominent and confluent; two small, horizontal, elongate, cervical sclerites present.

Labro-clypeus with its anterior margin nearly in line with the lateral expansions of the epistoma, quadridentate and possessing a row of four setæ. Left expansion slightly more prominent than the right, both rounded and bearing a few short setæ. Epipharynx spinous.

Ocular areas in groups of six and indistinct, arranged somewhat in a circle; the first three equidistant and with their axes nearly vertical, while the other three have their axes nearly horizontal.

Antennæ fairly short, barely exceeding the distal inner tooth of the mandible; first segment nearly equal to the second in width, a little longer and slightly constricted; second segment swollen somewhat in the middle and bearing a colorless, finger-like appendage, in addition to the sense-cones at the latter's base; third segment the same length as the appendage of the second segment, about twice as wide and long as the second segment, and bearing at its extremity several sense-cones and several long setæ.

Mandibles symmetrical, fairly prominent, sharply pointed at their tips and with three strong inner teeth, the anterior two about the same size and larger than the small basal tooth; molar areas smooth.

Maxillæ with joint-like palpifer; stipes large, swollen, slightly narrowed towards the apex, longer than the palpifer and palpus together, its inner surface provided with a row of five stout setæ, and two lateral slender setæ on its distal half, one placed behind the other; palpifer fairly large, about the same width as its palpus, nearly as wide as long, bearing a single, stout, inner, lateral seta near its base and a rudimentary lobe, possessing apical setæ; first segment of palpus about the same length as the rudimentary lobe of the palpifer and equal to the second in length and width, while

the third segment is about as long as the first two together and nearly as wide; each bears a few slender setæ, the terminal segment with a group of sense-cones at its extremity.

Labium slightly exceeding the inner distal tooth of the mandible; submentum small; mentum and palpiger cylindrical and about the same size; mentum with short, stout setæ mounted on tubercles; palpiger with a longitudinal row of three distal setæ on each side of the median line and an additional pair just inside the middle pair of the latter row; palpus with first segment short, second segment about three times as long and bearing sense-cones and setæ at its tip as well as at its base; ligula present and nearly as long as the second segment of the palpus.

Prothorax with sides slightly rounded, a little wider than the head; anterior margin of pronotum fringed with a row of minute setæ set close together; epicranial suture present; prosternum with two fairly large sclerites in front of the coxæ touching along the median line but not highly chitinized; meso- and metathorax shorter than the prothorax and about the same size as each other; the two sclerites of the mesonotum large, with the anterior margin of the whole concave; two triangular sclerites present in the pro-mesotergal suture; the spiracles on tubercles at the externo-frontal angles of the mesothorax; metanotum with two pairs of elongate sclerites; the caudal pair smaller and each with a prominent seta on its inner half.

Legs short, a little longer than one-half the width of the thorax but with just the distal end of the tibiæ and tarsi showing from above; coxæ transverse; femora a little longer than the tibiæ; tarsi claw-like, shorter than the latter, bearing a prominent inner seta, and another less prominent one towards the base; the two anterior coxæ are closer together than the four posterior coxæ, which are about the same distance apart.

Abdomen with eight distinct segments only slightly narrowed caudally, ninth and tenth segments forming the atrium. The first seven tergites similar and each with two transverse folds while the intersegmental membrane has only one. The *praescutum* of each of the first seven tergites bears a pair of small, oval, chitinized patches, the first pair being more prominent and elongate than the other six. A prominent lateral tubercle present on both the segment and the membrane, the one on the former being larger and more rounded than that on the latter. Below the lateral tubercle of the segment there are two others. The tubercles on the folds are hard to make out but are arranged in transverse rows as follows: six on the first fold of the segment, the middle pair united by a small narrow fold; eight on the second fold; and six on the intersegmental membrane, the middle pair united by a small narrow fold. The pair of tubercles on each side of the middle pair of tubercles of the second fold bear a seta. Each spiracle situated between the outer pair of tubercles of these first two folds. The eighth tergite represents the superior valve of the stigmatic atrium. The structure of the atrium is similar to that of *Laccobius*. The caudal border of the superior valve is nearly straight, slightly rounded in the middle. The procerci and especially the mesocerci are quite prominent; the lateral seta of each is slender but strong and slightly wavy.

FULL-GROWN LARVA.—Length, 3.76 mm. (5.11 mm. extended); width at the fourth abdominal segment, 1.21 mm.; depressed. Light yellowish; head and thorax darker than the abdomen with the exception of the abdominal tubercles, which are brownish and more pronounced than in the first instar. The tubercle on each side of the middle pair of tubercles on the second fold of each segment is the most prominent

of all the tubercles and together they form two longitudinal rows, especially distinct in freshly molted larvæ. The three pairs of lateral tubercles on each segment are very prominent. The sternites possess three folds and the ventral side of the intersegmental membrane one. The setæ on the anterior margin of the pronotum are sparser, about fifteen on each side of the median line, but longer, more prominent. Legs not visible from above. Dorsal plate of eighth segment slightly lobed medially at its caudal margin. Head, dorsally, 0.35 mm. long and 0.43 mm. wide; retractile as far as the ocular areas. Ligula longer than the second segment of the palpus. A transverse row of ten stout, dorsal setæ noted on the mentum nearly through the middle and directed forward; the inner two setæ seem to be on the epipharynx, which bears short and stout setæ.

PARACYMYUS Thomson (*ex parte Cryniphilus*)

As suggested under *Ancæna*, this genus is very closely allied to that one. They were formerly united under *Cryniphilus*. The ready characters which distinguish the single local species, *subcupreus*, from *Ancæna infuscata* have been given under that genus. Zambeu found the pupa of *Paracymus æneus* beneath a stone near water but his description was very superficial. This is the only observation made upon the life history of the genus, with the possible exception of the description of *Ancæna limbata*, which may in reality belong to *Paracymus*.

Paracymus subcupreus Say

Plate XVI

The eggs are not enclosed in a case but only covered with scattered threads of silk. Most of the egg-laying occurs in May but one egg-mass was obtained indoors on April 20. The number deposited varied from ten to fifteen, and the eggs usually hatched in about seven days.

Two pupæ were taken on July 19 from cells which were formed less than an inch below the surface of the ground and two feet from the edge of the water. The length of the pupal period was four days, as shown by a larva which was reared in the aquarium. It transformed on September 12 at noon and emerged on the afternoon of the 16th. Another pupa, collected on August 11 from a cell underneath a stone, came out on the 13th.

The adult, upon emergence, was colored as follows: head brown, with eyes darker; tips of the maxillary palpi almost black; antennal clubs white; thorax and scutellum brown but lighter than the head; legs light brown; elytra white except light brown margins along the median line; under side of abdomen white.

EGG-CASE.—Eggs are covered only with loosely applied silk and each measures 0.54 mm. in length and 0.027 mm. in width.

NEWLY HATCHED LARVA.—Length, 1.13 mm.; width, 0.288 mm. Whitish, except chitinated portions which are brownish; integument, including thoracic sclerites, dotted with minute setæ.

Head quadrangular, very slightly elevated; fronto-clypeal suture weakly indicated, more prominent at the sides; frontal sutures converging strongly caudally as far as the middle of the head, then slightly diverging to the posterior margin of the head; and united by a transverse suture which runs along the hind margin of the head so close that it is hardly noticeable; epicranial suture absent and the postfronto-vertical sclerites widely separated; gula reduced, pentagonal, with its sides concave, especially the latero-anterior ones; the anterior angles acute; gula sutures prominent and confluent; two, small, oval, cervical sclerites present.

Labro-clypeus tridentate, the outer two teeth bifid, with a row of four setæ, each of which is located between the five teeth. Left frontal angle slightly less prominent and less advanced than the right, which is nearly in line with the anterior margin of the labro-clypeus. Both angles rounded and bearing a few short setæ. Epipharynx spinous.

Ocular areas roundish; in groups of six and indistinct; arranged somewhat in a circle.

Antennæ fairly short, barely exceeding the distal inner tooth of the mandible; first segment a little wider and longer than the second and slightly indented on the inner side; second segment swollen and bearing a colorless, finger-like appendage, in addition to the sense-cones at the latter's base; third segment about the same length as the appendage of the second segment, two-thirds as long and half as wide as the second segment, and bearing several sense-cones and a prominent terminal seta.

Mandibles symmetrical, prominent, sharply pointed at their tips and with two strong inner teeth; serrations on the inner surface of the tip as well as on the inner surfaces of the inner two teeth but indistinct, those on the left mandible more prominent; molar areas smooth.

Maxillæ with joint-like palpifer; stipes large, swollen, very slightly narrowed towards the apex, much shorter than the palpifer and palpus together, with a stout inner disto-lateral seta (there may be a row but it was not observed) and a number of small, stout dorsal setæ mounted on tubercles; palpifer large, a little wider than long, bearing a single, stout, inner lateral seta near its base and a rudimentary lobe, possessing several short, apical setæ, besides a single longer seta; palpus slightly narrowed towards the apex, all segments about the same length; first segment nearly three times the length of the rudimentary lobe of the palpifer; the terminal segment with a group of sense-cones at its extremity; articulating maxillary piece well developed.

Labium slightly exceeding the distal inner tooth of the mandible; submentum very small; mentum subcordiform, narrower and shorter than the palpiger, which is broadened distally and bears a seta on each side of the median line near the anterior margin; palpus with second segment more slender, one and a half times as long as the first segment and possessing sense-cones at its extremity; ligula nearly as long as the palpus, apparently two-segmented, the first segment nearly as long as the first segment of the palpus

Prothorax with angles rounded, slightly wider than the head; pronotum well developed, entirely chitinized, two tubercles on each side of its caudal half, two setæ on each side just inside of the lateral half of the anterior margin; sagittal line present; prosternum chitinized in front of the coxæ. Meso- and metathorax shorter but slightly wider than the prothorax and about the same size as each other; mesonotum with two large, quadrangular sclerites almost as wide as the segment but not attaining the sides; a lateral tubercle on each side and a spiracle on the tip of a minute tubercle in front of each; metanotum with a pair of narrow, elongate sclerites on its anterior half; the posterior half with two areas, corresponding in position to the sclerites on the anterior half, chitinized and with two tubercles arising from each; a lateral tubercle bearing a short, colorless seta present on each side.

Legs short, not visible from above, about as long as half the width of the thorax; coxæ transverse and grooved to receive the femora; femora a little longer than wide; tibiæ about as wide as long and shorter than the femora; tarsi claw-like, inconspicuous, shorter than the latter, and bearing a single inner seta; the two anterior coxæ are closer together than the four posterior coxæ which are about the same distance apart.

Abdomen with eight distinct segments, the first three slightly widened, the next five narrowed very slightly caudally and the ninth and tenth forming the atrium. First seven tergites similar and each with three transverse folds, clearly defined only in the middle; intersegmental membranes with a single fold; each præscutum bears a pair of oval chitinized patches. The tubercles on the folds are arranged as follows: one each side of the first and third folds about half-way between the median line and the side of the segment; two tubercles on each side half-way between the former tubercles and the lateral tubercle of the segment; one placed nearly behind the other (the anterior one bears the spiracle); two on the second fold, each arising from an elongate chitinized area on each side of the median line; a dorsal tubercle on each side of the intersegmental membrane. The middle region of the membranes has a narrow, elongate, chitinized area. Spiracles on small tubercles. There are apparently three longitudinal rows of lateral tubercles, the dorsal two being the most prominent. The eighth tergite represents the superior valve of stigmatic atrium. The caudal margin nearly straight but indistinctly lobed. The mesocerci prominent and broadly dome-shaped.

FULL-GROWN LARVA.—Length, 4.57 mm. (extended); width, 1.02 mm. at the third abdominal segment; not depressed. Yellowish except tubercles, which are brownish and much more pronounced than in the first instar.

Head, dorsally, 0.4 mm. wide and 0.35 mm. wide; retractile. Epipharynx with spinous surface prominent. Antennal segments more elongate. Labro-clypeus with the teeth prolonged forward more distinctly, tridentate; lateral tubercles prominent and subconical. There are three transverse folds on each abdominal sternite and one on the ventral side of the intersegmental fold.

PUPA.—Length, 2.42 mm.; width at its thorax, 1.345 mm. Entirely whitish, except the eyes. Head smooth and bears two supraorbital styli. Pronotum smooth, its anterior margin somewhat trilobed and its posterior margin straight. The styli are arranged as follows: ten near the anterior margin, four¹ of which are on the middle lobe; ten² near the posterior margin counting the two corner ones; a transverse row

¹The outer two of these are more anterior in position than in *Cymbiodyta* or *Philydrus*.

²Medio-lateral setæ are more posterior so that they may be considered in the posterior row.

of four just a little anterior of the middle, with the outer two set a little more forward than the inner two. Metathoracic pterothecæ visible from above. Mesonotum and metanotum smooth, with a transverse row of two styli, each just lateral of the scutellum. Inner spur of metatibia not very prominent and blunt, no outer adjacent spur present. Tarsi not ending in a spine but blunt and tibiæ not noticeably spinous on the outer side, although all tibiæ have slight protuberances. First to seventh abdominal tergites with a transverse row of six styli, the outer one on each side arising from a tubercle; second to seventh pleurites each with a stylus; eighth tergite semicircular, the rounded posterior margin bearing two styli; ninth segment with a pair of tapering, fleshy cerci, about as long as the ninth tergite (0.215 mm.), extending caudally and slightly diverging. Externo-caudal angles of ninth sternite not prominent and acute. A pair of appendages arise from between the eighth and ninth sternites and extend caudally on either side of the median line to the base of the cerci and closely appressed to the ninth segment. Spiracles well defined but small.

9. *Sphæridiinae*¹

Eggs laid in a mass with a slight covering of loosely applied silk or a round blanket-like covering of closely applied silk (*Phænonotum*); deposited in dung, damp earth, or on damp leaves. Larva with head elevated; antennæ with their points of insertion situated farther from the externo-frontal angles of the head than those of the mandibles; epicranial suture absent; ocular areas flat, round, small, varying in size (first to third larger than fourth to sixth in *Phænonotum* and *Cælostoma*) and closely aggregated; labrum and clypeus reduced and united; with a small projection usually unidentate but tridentate in *Phænonotum*; antennæ with a more or less prominent antennal appendage; mandibles sharply pointed distally, strongly curved and with inner teeth, or without inner teeth and grooved on the inner side (*Sphæridium*); stipes widened and depressed on the outer side in *Sphæridium* and *Cercyon* but normal in *Phænonotum* and *Cælostoma*; stipes with many small setæ on its inner and outer sides; second segment of labial palpus distinctly longer than the first; labium and maxillæ inserted at the anterior margin of the under side of the head; the ventral side of the head in *Sphæridium* and *Cercyon* with the median line impressed and with a small pit in the middle; gula very much reduced and not attaining the occipital opening; jugular sclerites (in front of procoxæ) well developed; tarsi present (*Cælostoma*, *Phænonotum*), tarsi absent (*Sphæridium*), or legs entirely wanting (*Cercyon*). Eight complete abdominal segments; ninth and tenth reduced, forming a stigmatic atrium. Spiracles are rudimentary and bifore. Type of breathing is pseudo-metapneustic. Cerci reduced, two-segmented. The abdomen bears no chitinated plates and is more or less truncate. The larvæ show a tendency towards the scarabæoid type.

III. PHYLOGENETIC CONSIDERATIONS

Among the Hydrophilidæ there has been an evolution of distinct generic types. This is particularly evident among the larvæ and, in an endeavor to show the general trend of adaptation, a phylogenetic tree

¹This subfamily requires very much additional study but the characters thus far known and those taken from additional material at hand have been incorporated. The larvæ of *Phænonotum* and *Cælostoma* differ materially from those of *Sphæridium* and *Cercyon*.

(page 81), based entirely upon larval characters, has been erected. Just what value the larval characters have for purposes of classification is a question. As a rule, the larvæ and adults of this family appear to have evolved hand in hand but, in some cases, it is evident that one specialized while the other tended to remain primitive. Nevertheless, some value must be attached to these larval characters.

Many controversies have arisen over the question of what determines a primitive larva. Brauer, 1869, established the well-known law: "Je näher Larve und Imago einander und der form der Stammkerfe stehen, oder je weniger die imago, die Larve and vollkommener Organisation übertrifft, desto älter ist die Form." The essential thought of this law has stood ever since but qualifications have been necessary. Peyerimhoff, 1900, in discussing this law, stated that a careful examination of all parts is necessary to prove that a larva, apparently campodeiform, is absolutely primitive.

Lameere, 1899, believed that holometabolism was brought about by the boring of insects in vegetable tissues. As a result, an eruciform type of larva was evolved. In 1903, he said that Brauer's law could only be accepted for insects without metamorphosis and that supposed campodeiform larvæ of holometabolic insects are only campodeiform in appearance, being the result of ethological convergence. They are derived from eruciform larvæ adapted to feeding on vegetation. The larvæ of the primordial holometabolic insects thus acquire these special characters only through the influence of similar habits.

It was the belief of Gangldauer, 1904, that the Hydrophilidæ constitute a terminal family of a primitive branch of Coleoptera whose stock has been lost. The natural place, he said, is between the Staphylinidæ, with which they agree in the presence of larval cerci, and the Diversicornia, with which they agree in venation. He thus indicated that the Diversicornia, which he had established in 1902, was not monophyletic; and, at the same time, he indirectly accepted Lameere's grouping of the Hydrophilidæ under the suborder Palpicornia. This is apparently the most logical place for the family.

In this paper the true campodeiform larva has been considered as the most primitive type. By true campodeiform larva is meant that type of campodeiform larva which has not been evolved by ethological convergence, but one which is strictly primitive. One finds but little difference between *Limnebius*, *Hydræna*, etc., and the primitive type. A careful examination of the specific parts in these genera reveals only such characters as are fundamentally primitive. Apparent vestiges of

the maxillulæ, which Carpenter noted in the *Diversicornia*, are to be found at the sides of the hypopharynx in these forms and bear further testimony to their primitive position.

The following larval characters are considered primitive.

1. True campodeiform type of body.
2. Well chitinized integument.
3. Head inclined.
4. Ocular areas in groups of five.
5. Antennæ three-segmented and with their points of insertion nearer the externo-frontal angles than those of the mandibles.
6. Labrum and clypeus distinct and well developed.
7. Mandibles with a *lacinia mobilis*.
8. Maxilla with a well-developed inner lobe.
9. Presence of rudimentary maxillulæ.
10. Labium short with complex ligula and palpi.
11. Gula well developed and attaining the occipital opening.
12. Labium and maxillæ inserted in a furrow on the under side of the head.
13. Legs well developed; tarsi without claws but claw-like.
14. Holopneustic type with annuliform spiracles.
15. Cerci three-segmented.
16. Ten abdominal segments.

The number of eggs deposited and the manner in which they are protected are both important in phylogeny. The eggs of the most primitive genera are laid singly and without a silken covering or, at the most, with only a slight covering. On the other hand, many eggs are deposited in a mass and enclosed in a complex case by the members of those genera best adapted to aquatic life.

The pupæ of the most primitive genera have not been described. The genera best adapted to water show a reduction in the number of pronotal styli and an increase in the distinctness of the annulations of these styli. The cerci become stouter and more complex, as shown by the possession of spines, more distinct annulations, and bifid shape.

The most striking character of phylogenetic importance which appears among the adults is, without doubt, the number of abdominal sternites. Those genera possessing six or more sternites have larvæ which show a small indication, at least, of their evolution from the primitive type. *Berosus* and *Laccobius* still possess a vestige¹ of a furrow on the under side of the head. All other Hydrophilidæ have five abdominal sternites². Neither the antennæ nor the tarsi are apparently stable adult characters and the venation requires further study.

¹This evidently represents the former insertion of the labium and maxillæ in a groove on the under side of the head, and is primitive for hydrophilid larva.

²*Spercheus* larvæ show primitive tendencies but the adult possesses only five abdominal sternites.

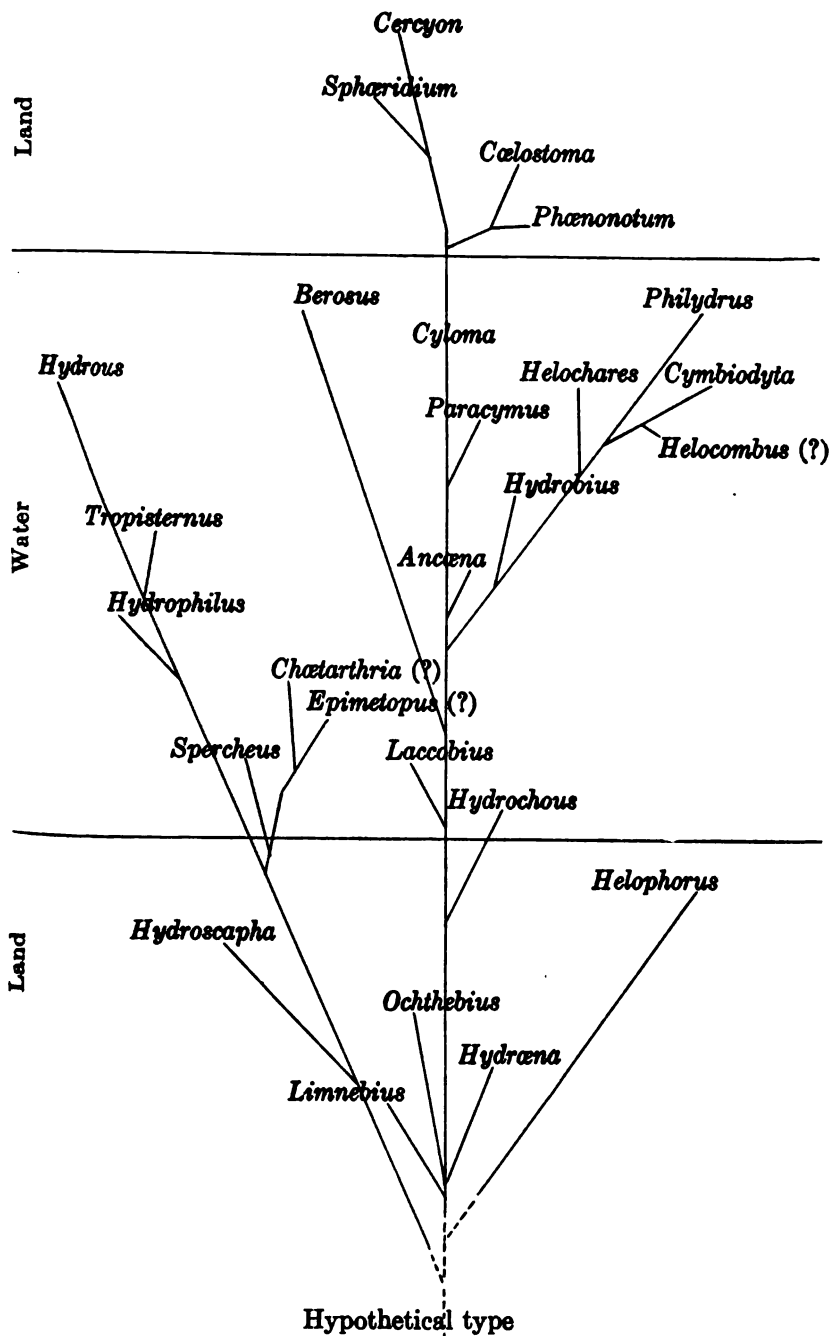
Ganglbauer divided the family into five subfamilies: Helophorinæ; Hydræninæ; Sphercheinæ; Hydrophilinæ; and Sphæridiinæ. It will be seen that four more have been considered here. Recent authors have laid stress upon larval characters in the determination of subfamilies. Limnebiini was raised to subfamily rank by d'Orchymont, 1913, and Hydroscaaphidæ was placed under the Hydrophilidæ, as Hydroscaaphinæ, by Böving, 1916. If the larval characters are to be accepted, surely the Hydrobiini and Hydrochoini are worthy of subfamily rank. The structures which characterize the immature stages of these subfamilies are listed on pages 27 and 42 respectively. The adult characters offer differences as well. The Hydrobiinæ differ strikingly from the Hydrophilinæ in general form, the latter being very much better adapted to water life. The Hydrochoinæ possess only seven-segmented antennæ (the last three segments pubescent) and six abdominal sternites, the second to fifth furrowed and the sixth unchitinized but prominent. The Hydræninæ, with which Ganglbauer linked them, possess eight- to nine-segmented antennæ (the last five segments pubescent) and six or seven smooth, chitinized, abdominal sternites.

An examination of the phylogenetic tree will show three branches near the base. The one to the left shows the trend of the Hydroscaaphinæ, Sphercheinæ and Hydrophilinæ. In these subfamilies, we find the tendency to develop gills at first and then finally lose them. The branch at the right shows the divergence of the Helophorinæ,¹ as represented by *Helophorus*, from the primitive types of the Limnebiinæ¹ and Hydræninæ. Ganglbauer considered Helophorinæ more primitive than those which have been placed nearer the base but the only character which could possibly suggest a more generalized larva is its three-segmented cerci. In its other structures it is very much more specialized.

On the main branch, Limnebiinæ and Hydræninæ are near the base and lead toward the Hydrobiinæ, with the Hydrochoinæ representing the stepping-stone. The latter subfamily clearly bridges the gap between the land forms and the water forms. *Berosus*, in its adaptation to water, is clearly the most advanced of the Hydrobiinæ. The pleural gills are remarkably well developed and only a slight indication of a former stigmatic atrium is discernible.

The branch with *Hydrobius*, *Helocombus* (?), *Cymbiodyta* and *Helochara* shows a tendency to a sublinear form and the gradual reduction of the number of inner teeth on the mandibles. It terminates in *Philydrus*,

¹The larva of *Helophorus* closely resembles that of *Hister*, while the larvæ of the Limnebiinæ are strikingly similar to those small Staphylinidæ, belonging to the Tachyporini, and to *Choleva*, *Liodes*, and *Agathidium* of the Silphidæ.



PHYLOGENETIC TREE BASED UPON LARVAL CHARACTERS

a genus possessing larval prolegs and manifesting a relationship to the eruciform type of larva.

Ancæna and *Paracymus*, with the gradual reduction of legs, lead through *Cyloma*¹ to the *terminus terrestris*, the subfamily Sphæridiinae.

IV. KEYS

An attempt is made to separate the genera in their immature stages. Schiödt, 1862, gave excellent keys, written in Latin, for all the stages, but they are necessarily incomplete. The main divisions of his pupal key have been incorporated here. The only contemporary work of note is the larval key given by d'Orchymont, 1913. His grouping of the genera is a very natural one; however, on account of additional material, new keys have been considered advisable. Representatives of all the genera have been examined with the exception of *Cercyon*, the data for which have been taken from literature.

KEY FOR THE IDENTIFICATION OF THE EGG-CASES

- | | |
|--|---|
| 1. Eggs laid singly | 2. |
| Eggs laid in a mass | 5. |
| 2. Covered with silk, either closely or loosely applied | 3. |
| Entirely naked | <i>Ochthebius</i> (in part); <i>Hydroscapha</i> . |
| 3. Silk loosely applied, eggs visible | <i>Ochthebius</i> (in part); <i>Limnebius</i> . |
| Silk closely applied, only contour of egg visible | 4. |
| 4. Eggs not entirely enclosed, with only a blanket-like covering, nearly regular in outline, oval | <i>Hydræna</i> . |
| Egg entirely enclosed, irregular in outline, with little stanchions .. | <i>Hydrochous</i> . |
| 5. Egg-mass covered with closely applied silk, eggs invisible | 6. |
| Egg-mass covered with silk, eggs visible | 17. |
| 6. With a prominent projection at the cap end (armed) | 7. |
| Without a prominent projection (unarmed). The projection, if present, is represented only by small strands | 14. |
| 7. Projection ribbon-like | 8. |
| Projection spine-like | 12. |
| 8. Projection tubular | 9. |
| Projection flattened | 11. |
| 9. Tubular projection opened distally | <i>Helophorus</i> . |
| Tubular projection closed distally | 10. |

¹The *Cyloma* larva is not known, but the adult, according to Ganglbauer, shows the relationship of the Hydrobiini to the Sphæridiinae.

10. Projection distinctly tubular proximally. Case proper nearly spherical.
Laccobius; Ancæna.
 Projection not distinctly tubular proximally. Case somewhat chestnut-shaped.
 Contour of eggs visible at the cap end.....*Berosus.*
11. Filament broader and often surrounding the cap end. Case nearly spherical.
Hydrobius.
 Filament narrower. Case proper more elongate and smaller.....*Philydrus.*
12. Cases (free floating) noticeably larger. Cap hatchet-shaped and not covering entire end.....13.
 Cases (attached to aquatic vegetation) smaller. Cap round and covering entire end.....*Tropisternus.*
13. Case naked, spine-like projection stout.....*Hydrous.*
 Case enwrapped in a leaf, spine-like projection slender and tip often bent over.
Hydrophilus.
14. Eggs laid on damp leaves (blanket-like covering of silk).....*Phænonotum.*
 Case carried on the under side of the body by the female.....15.
15. Case attached to the hind legs.....16.
 Case held in place by the elytra and modified abdominal segments.
Epimelopus; Chætarthria?
16. To the femora only.....*Helochares.*
 To the femora and tibiæ.....*Spercheus.*
17. Egg-mass deposited near the water, usually under fallen leaves.....18.
 Egg-mass deposited in dung or damp earth.....19.
18. Egg-mass usually larger. Number of eggs varies from 15-43.....*Cymbiodyta.*
 Egg-mass usually smaller. Number of eggs varies from 10-15.....*Paracymus.*
19. Egg-mass larger.....*Sphæridium.*¹
 Egg-mass smaller.....*Cercyon* (?).

KEY FOR THE IDENTIFICATION OF THE LARVÆ

1. Nine complete abdominal segments, the tenth reduced but distinct. Integument noticeably chitimized.....2.
 Eight complete abdominal segments, the ninth and tenth reduced and forming a stigmatic atrium (except in *Berosus* in which the atrium has not developed). Integument not noticeably chitimized (except in *Hydrochous*).....6.
2. Head inclined; epicranial suture present; ocular areas in groups of five; mandible with *lacinia mobilis*: maxilla primitive with prominent inner lobe; labium and maxillæ inserted in a furrow on the under side of the head; gula well developed and attaining the occipital opening. Cerci absent or well developed and two-segmented.....3.

¹No account is given of the eggs of *Sphæridium* or *Cercyon* except the situation in which they are laid. I have observed only a single mass of *Sphæridium* eggs.

Head slightly elevated, nearly horizontal; epicranial suture absent; ocular areas in groups of six; mandibles sharply pointed, with inner teeth; maxilla palpiform; labium and maxilla inserted at the anterior margin of the under side of the head; gula reduced and distant from the occipital opening. Cerci well developed and three-segmented. *Helophorus*.

3. Antennæ very short; ocular areas aggregated; clypeus lacking or fused with labrum; no well-defined spiracles; tracheal gills on the prothorax, and first and eighth abdominal segments; cerci absent; each abdominal segment with a continuous band of chitin; tenth or anal segment with a ventral sucker and two terminal pencil-shaped appendices. *Hydroscapha*.

Antennæ rather long; ocular areas distant; clypeus and labrum both distinct; nine pairs of annuliform spiracles; no tracheal gills; cerci two-segmented and well developed; each abdominal segment with a ventral and dorsal plate of chitin; tenth or anal segment without a ventral sucker and with two small terminal hooks. 4.

4. Antennæ usually shorter, with no prominent inner swellings; setæ on the clypeus not placed at the anterior margin and the two median ones distant from each other; *lacinia mobilis* narrower; inner lobe of maxillæ not distinctly divided apically; cerci nearly contiguous proximally and divergent. *Ochthebius*.

Antennæ usually longer, with prominent inner swellings; setæ on the clypeus placed at the anterior margin and equidistant; *lacinia mobilis* broader; inner lobe of maxillæ distinctly divided apically; cerci widely separated proximally and nearly parallel. 5.

5. Third segment of antennæ without inner swellings, second segment with a single antennal appendage; a pair of pectinate setæ at the anterior margin of the labrum; inner lobe of maxillæ slightly divided apically; labium broadened distally. *Hydræna*.

Third segment of antennæ with an inner swelling; second segment with two slender antennal appendages; no pectinate setæ at the anterior margin of the labrum; inner lobe of maxillæ strongly divided; labium not noticeably broadened distally, although sides of mentum are rounded. *Limnebius*.

6. Head slightly inclined or horizontal; antennæ with their points of insertion nearer the externo-frontal angles than those of the mandibles; ocular areas in groups of five or six; labium and maxillæ inserted in a furrow on the under side of the head; gula well developed and attaining the occipital opening. 7.

Head elevated; antennæ with their points of insertion farther from the externo-frontal angles than those of the mandibles; ocular areas in groups of six; labium and maxillæ inserted at the anterior margin of the under side of the head; gula reduced and not attaining the occipital opening. 8.

7. Ocular areas in groups of five, not aggregated; epicranial suture very short, nearly absent; mandibles sharply pointed and with inner teeth; palpifer with an inner claw-like lobe; abdominal segments without chitinous plates.

Spercheus.

Ocular areas in groups of six, aggregated; epicranial suture entirely absent, each mandible with a terminal seta, inner tooth and *lacinia mobilis*; palpifer with the inner rudimentary lobe not claw-like; abdominal segments with well-developed chitinous plates. *Hydrochous*.

8. Type pseudo-apneustic. Seven pairs of very prominent tracheal gills present on the abdomen. Ninth and tenth abdominal segments very much reduced and no stigmatic atrium present. *Berosus*.

Type pseudo-metapneustic. Tracheal gills not nearly as prominent or absent. Ninth and tenth abdominal segments reduced, forming a stigmatic atrium. . 9.

9. Ocular areas round, usually small and more closely aggregated; legs reduced or absent; pleural lobes not prominent; abdomen truncate. 19.

Ocular areas oval, larger, aggregated but more distant; legs well developed, visible from above except in *Paracymus*; pleural lobes usually prominent; abdomen not noticeably truncate, more or less elongate. 10.

10. First segment of antennæ not distinctly longer than the following two taken together; finger-like antennal appendage present; labro-clypeus with teeth usually well defined; mouth-parts stouter; mandibles not grooved internally; stipes large and swollen, usually with an inner row of five stout setæ; externo-frontal angles of mentum not prominent, rounded; legs much shorter, femora without fringes of swimming hairs; gills and prostyles absent. 11.

First segment of antennæ distinctly longer than the following two taken together; finger-like antennal appendage absent; labro-clypeus with teeth small or absent; mouth-parts more slender; mandibles grooved internally; stipes not swollen, with setæ arranged differently; externo-frontal angles of mentum prominent and acute; legs very long; femora with fringes of long swimming hairs; gills present (*Hydrophilus*, *Tropisternus*) or absent (*Hydrous*); prostyles present. 17.

11. Frontal sutures parallel and not uniting to form an epicranial suture; left expansion of epistoma much more prominent than the right and with a row of stout setæ; ligula absent; reduced sclerites of meso- and metathorax widely separated; tarsus well developed, about as long as tibia. *Laccobius*.

Frontal sutures not parallel and may or may not unite to form an epicranial suture; lateral expansions of epistoma similar and usually in line with the anterior margin of the labro-clypeus, no rows of stout setæ except in *Hydrobius*; ligula present and longer than the first segment of the palpus; sclerites of meso- and metathorax reduced but not so widely separated; tarsus less developed usually much shorter than the tibia. 12.

12. Antennæ shorter and antennal appendage more prominent, especially in the first stage larva; epicranial suture absent; legs reduced; abdomen more truncate; cercus with long terminal seta. 13.

Antennæ longer and antennal appendage less prominent; epicranial suture present but usually short; legs fairly long, not reduced; abdomen narrowed caudally; cercus with a shorter terminal seta. 14.

13. Frons truncate behind; labrum tridentate, the lateral teeth bifid; mandibles symmetrical, each with two inner teeth; palpiger enlarged in front; ligula about as long as palpi, apparently two-segmented; anterior margin of pronotum without a fringe of stout setæ; legs not visible from above. . . . *Paracymus*.
Frons rounded behind; labrum quadridentate; mandibles symmetrical, each with three inner teeth; palpiger not enlarged in front; ligula not as long as the palpi, one-segmented; anterior margin of pronotum with a fringe of stout setæ; legs barely visible from above. *Ancæna*.¹
14. Mandibles symmetrical, each with two or three inner teeth; abdomen without prolegs. 15.
Mandibles asymmetrical, the right with two inner teeth, the left with only one; abdomen with prolegs on the third to seventh segments. . . . *Philydrus*.
15. Labro-clypeus with five distinct teeth, the outer left tooth a little distant from the rest; each mandible with three inner teeth; mentum subquadrangular. *Hydrobius*.
Labro-clypeus with at least six teeth; each mandible with two inner teeth; mentum cordiform. 16.
16. Labro-clypeus with six distinct teeth, placed in two groups, two on the left and four on the right, mentum covered with small spines; anterior sclerites of the metathorax with caudal projections. *Helochares*.
Labro-clypeus with more than six teeth, those towards the right not clearly defined and with several smaller teeth; mentum with small spines only towards the base; anterior sclerites of the metathorax without caudal projections, rectangular. *Cymbiodyla*.
17. Head subspherical; labro-clypeus without teeth; each mandible with a single inner tooth; ligula not longer than first palpal segment; gills absent; pronotum not entirely chitinated. *Hydrous*.
Head subquadrangular, narrowed behind; labro-clypeus with inconspicuous teeth; each mandible with more than one, usually with two inner teeth; ligula distinctly longer than first palpal segment; pronotum entirely chitinated, gills present but more or less rudimentary. 18.
18. Mentum transverse; sides only slightly rounded; fronto-external angles very prominent; pleural gills rudimentary but indicated by tubercular projections, each with several terminal setæ. *Tropisternus*.
Mentum, convex, with its sides strongly rounded towards its basal half, its sides serrate in the last instar; fronto-external angles less prominent; pleural gills fairly well developed and pubescent. *Hydrophilus*.²
19. Head ovate or subspherical; antennal appendage shorter; mandibles asymmetrical; stipes broadened and depressed on its outer side; ligula³ exceeding the palpi and pointed; median line on ventral side of the head impressed and with a small pit mid-way; legs incomplete; abdomen without ventral suckers.

20.

¹The characters found in *Ancæna infuscata* are incorporated here. It seems possible that *Ancæna limbata*, the larva of which d'Orchymont, 1913, described, may really belong to the genus *Paracymus*, as its characters more closely resemble the latter genus.

²D'Orchymont says in his key that the tarsus of *Hydrophilus* is toothed on the inner side, but only the two inner setæ are found in *H. obtusatus*.

³The specimens at hand do not show the ligula formed as described here, but more larvæ will have to be examined before Schiödte's figure is discredited.

Head quadrangular; antennal appendage about the length of the third segment; mandibles symmetrical, each with two inner teeth; stipes swollen, not broadened or depressed externally; ligula about as long as the first palpal segment and not pointed; median line not impressed and pit absent; legs reduced but complete; each abdominal segment with a ventral sucker.....21.

20. Head subspherical; ocular ares aggregated but more distant from each other; mandibles without inner teeth, furrowed on the inner side; mentum cordiform; tarsi absent; procercus and appendage of seventh intersegmental membrane fleshy and long.....*Sphaeridium*.

Head ovate; ocular areas closely aggregated and sometimes appearing as one; right mandible with a single inner tooth; mentum short, transverse; legs absent; procercus and appendage of the seventh intersegmental membrane reduced and barely indicated.....*Cercyon*.

21. Clypeus tridentate.....*Phænonotum*.
Clypeus unidentate.....*Cælostoma*.

KEY FOR THE IDENTIFICATION OF THE PUPÆ

1. Metathoracic wing-cases visible from above.....2.
Metathoracic wing-cases not visible.....9.
2. Motary styli of abdominal tergites in transverse rows of six each; abdominal tergites with small lateral tubercles; spiracles not hidden; abdominal pleurites confused with the tergites.....7.
Motary styli of abdominal tergites in transverse rows of four each; abdominal tergites with large lateral tubercles; spiracles not hidden but partly concealed by the lateral tubercles of the tergites; abdominal pleurites well defined...3.
3. Supraorbital styli less than two in number; metasternal spine and inner spur of metatibia prominent; eighth abdominal tergite with two small, rounded tubercles, each bearing a terminal stylus at the posterior margin.....6.
Supraorbital styli two in number; no metasternal spine; inner spur of metatibia not prominent; eighth abdominal tergite without tubercles as above...4.
4. Pronotal styli 16 in number, all situated near the margins; cerci short.
Helophorus.
Pronotal styli 24-26 in number, all of them not situated near the margins; cerci long.....5.
5. Pronotal styli 26 in number, long and slender; abdominal styli varying in size, the lateral tergal styli very long and slender, the pleural styli very short and conical; eighth abdominal tergite without appendages resembling cerci; externo-caudal angles of ninth segment not acute; cerci long, very crooked and multiannulate distally.....*Berosus*.
Pronotal styli 24 in number; abdominal styli subequal; eighth abdominal tergite with a pair of appendages resembling cerci; externo-caudal angles of ninth segment prominent and acute; cerci long, only slightly crooked and apparently not annulate.....*Laccobius*.

6. Larger in size, more than 25 mm. long; one supraorbital stylus; only 16 well-developed pronotal styli but several other inconspicuous ones; cerci nearly 3.5 mm. long, superficially annulate, and not bifid (?).....*Hydrous*.
Smaller in size, less than 12 mm. long; no supraorbital styli; 22 well-developed pronotal styli; cerci about 1.45 mm. long, superficially annulate, slightly bifid and acute.....*Tropisternus*.
7. Larger in size, more than 13 mm. long; pronotal styli numerous, 32 in number; eighth abdominal tergite with two, small, rounded tubercles, each bearing a short terminal stylus; cerci slightly bifid and acuminate.....*Hydrophilus*.
Smaller in size, less than 8 mm. long; pronotal styli fewer, 24 in number; eighth abdominal tergite without the tubercles mentioned above but with a pair of styli; cerci not bifid, acuminate or thread-like distally.....8.
8. Smaller in size, less than 3 mm.; styli are short with long terminal setæ; the styli at the anterior margin of the pronotum 10 in number, four in the middle and three towards each side.....*Paracymus*.
Larger in size, more than 3 mm.; styli not noticeably short nor the terminal seta long, about equal to each other; the styli at the anterior margin of the pronotum 6 in number, two in the middle and two towards each side; the two end styli on each side, which were present in the above, have moved to a distinct lateral position.....*Cymbiodyta*; *Philydrus*; *Helochares*.²
9. Abdominal pleurites often confused with the tergites; cerci long, slender, acuminate, multiannulate.....*Cercyon*.
Abdominal pleurites distinct; cerci short, conical, two-segmented...*Sphæridium*.

V. LITERATURE

- BAKER, W. F. 1894. *Hydrobius fuscipes*, metamorphoses, larval anatomy, etc. Naturalist, pp. 327-333.
- BALFOUR-BROWNE, FRANK. 1908. British species, claws, etc., of *Philhydrus*. Ent. Rec., XX, pp. 25-29, Pl. iv.
1910. On the life-history of *Hydrobius fuscipes* L. Trans. R. Soc. Edinburgh, XLVII, pp. 317-340, Pl. III.
1913. The Life-history of a water-beetle. Nature, XCII, pp. 20-24. London.
- BARBER, H. S. 1906. The Spread of *Sphæridium scarabæoides*. Proc. Ent. Soc. Washington, VII, pp. 127-128.
- BERLESE, ANTONIO. 1909. *Hydrobius fuscipes*; *Hydrophilus piceus*; *Berosus spinosus*. Gli Insetti, I, pp. 55, 832, 875.
- BEUTENMÜLLER, WILLIAM. 1891. Bibliographical catalogue of the described transformations of N. A. Coleoptera. Journ. N. Y. Micros. Soc., VII, pp. 5-6.
- BLATCHLEY, W. S. 1910. Family Hydrophilidæ, the water scavenger beetles. Coleoptera of Indiana, pp. 247-271.

¹The cerci are broken off in the specimen at hand. They are probably not bifid, as Matheson, 1914, does not mention it in *H. triangularis*.

²There appear to be no distinct characters for the separation of these three genera. The arrangement of the pronotal setæ differ slightly but cannot be incorporated into the key. Examination of the metathoracic tarsus shows, however, the four-segmented condition in *Cymbiodyta* and the five-segmented in *Philydrus* and *Helochares*.

- BÖVING, ADAM GIEDE. 1914. Notes on the larva of *Hydrosapha* and some other aquatic larvæ from Arizona. Proc. Ent. Soc. Washington, XVI, pp. 169-174, Pls. xvii-xviii.
- 1914a. On the abdominal structure of certain beetle larvæ of the campodeiform type. A study of the relation between the structure of the integument and muscles. Proc. Ent. Soc. Wash., XVI, pp. 55-63, Pls. iii-iv.
- BOWDITCH, F. C. 1884. *Hydrocharis obtusatus*. Journ. Boston Zool. Soc., III, pp. 1-6.
- BROCHER, FRANK, 1911. *Berosus ariceps*. Egg, early stages. Observations biologiques sur quelques insectes aquatiques. Ann. Biol. lacustre, Bruxelles, IV, pp. 367-379.
1912. Recherches sur la respiration des insectes aquatiques adultes. L'Hydrophile. Étude physiologique et anatomique. Ann. Biol. lacustre, Bruxelles, V, pp. 1-39, Figs. 1-22.
1912. Recherches sur la respiration des insectes aquatiques. Hydrophile, etc. Soc. Entomol., Stuttgart, Jahrg. XXVII (No. 21), pp. 91-93; Jahrg. XXVII (No. 22), p. 102.
1913. L'Appareil stridulatoire de "*Hydrophilus piceus*" et celui du "*Berosus ariceps*." Ann. Biol. lacustre, Bruxelles, V, pp. 215-217.
- BUHK, F. 1910. Lebensweise und Entwicklung von *Spercheus emarginatus*. Entomol. Rundschau, Stuttgart, XXVII, pp. 127-128, 134-136.
- CALWER, C. G. 1883. Käferbuch, Naturgeschichte der Käfer Europas, pp. 81-90, Taf. ix, figs. 1-4; Taf. viii, figs. 24-30.
- COMSTOCK, JOHN HENRY. 1907. Family Hydrophilidæ. Manual for the Study of Insects, pp. 527-529.
- CUSSAC, EMILE. 1852. Mœurs et Métamorphoses du *Spercheus emarginatus* et de l'*Helochares lividus*. Ann. Soc. Ent. France, X, pp. 617-625, Figs. 8-26, Pl. xiii.
1855. Mœurs de l'*Hydrobius fuscipes* Linné. Ann. Soc. Ent. France, (3) III, pp. 246-247; Pl. xiii, No. 1.
- DEEGNER, P. 1913. Respirations Organe. Handbuch der Entomologie. Jena. Band I (Kapitel 5), p. 363, Fig. 262.
- DONISTHORPE, H. 1900. Notes on the copulation of *Hydrophilus piceus*. Ent. Rec., XII, p. 291.
- DUGÈS, EUGÈNE. 1884. Métamorphoses du *Tropisternus lateralis* Fab. Ann. Soc. Ent. Belg., XXVIII, pp. 7-12; Pl. i, part 2.
- ERICHSON, W. F. 1841. *Hydrous* larva. Archiv für Naturg., VII Jahrg. (1 Bd.), pp. 108-110.
- FALL, H. C. 1901. List of the Coleoptera of Southern California with notes on habits and distribution and descriptions of new species. Occasional papers of the Cal. Acad. Sci., VIII, pp. 12, 16, 55-58, 81, 213-218.
- FOLSOM, J. W. 1909. Adaptations of aquatic insects. Entomology with reference to its biological and economic aspect, pp. 184-192.

- FRICKEN, W. VON. 1887. Entwicklung, Atmung und Lebensweise der Gattung *Hydrophilus*. Tageblatt der XL Versammlung deutscher Naturforscher und Ärzte. Wiesbaden, pp. 114-115.
- FRISCH, JOHANN LEONARD. 1721. Beschreibg. von allerley Ins. in Deutschl., VI, pp. 26-32, Tab. vi, figs. 1-6.
- GANGLBAUER, LUDWIG. 1899. *Hydroscaphidæ*. Käfer von Mitteleuropa. III, pp. 332-335.
1904. *Hydrophilidæ* of Europe. Die Käfer von Mitteleuropa, VIII, pp. 141-286.
- GARMAN, H. 1881. *Hydrophilus triangularis* Say. Ann. Nat. Hist., XV, p. 66.
- HALIDAY, A. H. 1855. *Ochthebius punctatus*. Natural Hist. Review, Proceed. London, II, p. 116, Pl. III, fig. 3.
1856. *Ochthebius punctatus*. Natural Hist. Review, Proceed. London, III, p. 20.
- HART, C. A. 1895. On the Entomology of the Illinois River and Adjacent Waters. Ill. State Lab. of Nat. Hist., IV, pp. 149-270, Pl. xv.
- HAUPT, H. 1907. Was mich eine *Hydrophilus* (*Hydrous*) Larve lehrte. Wochenschrift Aquarienkunde, Braunschweig, IV, pp. 326-328.
1909. Biologie de Larve *Hydrous* (*Hydrophilus*). In Zs. Natw. Leipzig, LXXXI, pp. 301-304.
- HENNEGUY, L. 1904. Hydrophili-types of development. Les insectes, pp. 320-322.
- HENSHAW, SAMUEL. 1885. List of the Coleoptera of America, north of Mexico. Amer. Ent. Soc., pp. 23-25.
- HENTSCHEL, ERNEST. 1909. Das Leben des Süßwasser. *Hydrophilides*, p. 291; *Hydrophilus*, pp. 53, 192, 197, 235; *Hydrous*, p. 236.
- HOPKINS, A. D. 1911. Contribution toward a Monograph of the Scolytid Beetles. I. Genus *Dendroctonus*. Tech. Series, No. 17, part 1, p. 164, fig. 95; Pls. III-VIII.
- HORN, GEORGE W. 1876. Synoptic tables of some genera of Coleoptera. Trans. Amer. Entom. Soc., V, pp. 251-252.
1890. Notes on the species of *Ochthebius* of boreal America. Trans. Amer. Ent. Soc., XVII, pp. 17-26, Pl. II.
- 1890a. Notes on some Hydrobiini of boreal America. Idem, pp. 237-278, 279-314.
- KIRBY, W. F. 1892. Palpicornia. Text book of Entomology, pp. 23-24, Figs. 9-13.
- LACORDAIRE, TH. 1854. Histoire Naturelle des Insectes, Genera des Coléoptères, I, pp. 443-475.
- LAKER, ABBOTT G. 1881. The cocoons of *Hydrophilus piceus* and *Hydrobius fuscipes*. Newman's Entomologist, XIV, pp. 82-84.

- LAMEERE, AUGUST. 1899. Les Métamorphoses des insectes. Ann. Soc. Ent. Belg., XLIII, pp. 619-636.
1900. Notes pour la classification des Coléoptères. Ann. Soc. Ent. Belg., XLIV, pp. 365-366.
1903. Nouvelles notes pour la classification des Coléoptères. Ann. Soc. Ent. Belg., XLVII, pp. 155-165.
- LAMPERT, KURT. 1910. Das Leben der Binnengewässer, pp. 126-129, Figs. 43-44.
- LECONTE, JOHN L. AND HENSHAW, SAMUEL. 1861. Classification of the Coleoptera of North America. Smithsonian Miscellaneous Collection, part I, pp. 43-47.
- LECONTE, JOHN L., AND HORN, GEORGE H. 1883. Coleoptera of North America. Hydrophilidæ, pp. 69-73.
- LEFROY, H. MAXWELL. 1909. Indian insect life, Pusa, pp. 283-286.
- LETZMER, K. 1853. Denkschr. zur Feier ihres 50-jähr. Bestandes, herausgegeben von der Schles. Ges. für vaterl. Kultur, Breslau, II, pp. 212-213, Figs. 31-33.
- LYONET, PIERRE. 1832. Recherches sur l'anatomie et les métamorphoses de différentes espèces d'insectes, pp. 129-151, Pl. XIII (Figs. 47-50).
- MACGILLIVRAY, A. D. 19—. Key to families of coleopterous larvæ. New York State Mus. Bull., LXVIII (Ent. 18), pp. 289-294.
- MATHAN (DE) M. 1865. Note sur l'*Ochthebius lejolisi* Muls. et Rey, avec notes rectificatives de M. A. Fauvel. Ann. Soc. Ent. France, (4) V, pp. 199-202, Figs 1-5.
- MEGUSAR, FRANZ. 1906. Einfluss abnormaler Gravitationswirkung auf die Embryonalentwicklung bei *Hydrous aterrimus* Eschscholtz. Archiv für Entwicklungsmechanik, Leipzig, XXII, pp. 141-148, Figs. 1-3.
1907. Die Regeneration der Koleopteren. Archiv für Entwicklungsmechanik, XXV, pp. 148-218, Pl. VII.
1909. Lebensgeschichte, Hydrophilidæ. Verh. Zool. Bot. Ges. Wien, LIX, pp. 278-287.
- MEINERT, FREDERICK. 1897. Ombygningen hos Insekterne. (On the mouth-parts of insects.) Oversigt over det. Kgl. Danske Videnskabernes Selskabs Forhandlinger. Nr. III, pp. 299-324, Figs. 1-14.
- MIALL, L. C. 1895. Aquatic beetles. The natural history of aquatic insects, pp. 61-93.
- MIGER, FELIX. 1809. Mémoire sur les larves d'insectes Coléoptères aquatiques, 1er Mém. sur le grand Hydrophile. Ann. du Mus. d'Hist. Nat., XIV, pp. 441-459; Pl. xxviii, Figs. 1-9.
- MJOBERG, ERIC. 1906. *Cercyon littoralis*, early stages. Zs. wiss. Insektenbiol., Husum, p. 138.
- MULSANT, ETIENNE. 1844. Histoire naturelle des Coléoptères Palpicornes. pp. 1-196, Figs. 1-21.

- MULSANT, ETIENNE AND REY, CL. 1861. *O. lejolisi*. Mém. soc. imp. sc. nat., Cherbourg, VIII, pp. 184-186, Fig. 2.
- D'ORCHY-MONT, A. 1913. Contribution a l'étude des larves Hydrophilides. Ann. de Biol. Lacustre, VI, pp. 173-214, Pls. I-XXIII.
- PACKARD, A. S. 1872. Guide to the Study of Insects, pp. 437-438.
- PAGANETTI-HUMMLER, G. 1899. Coleopterologische Liebesszenen der Ochthebien. Zeitschr. f. Ent., IV, p. 107.
- PERRIS, EDOUARD. 1876. Nouvelles promenades entomologiques. *Helophorus rugosus*. Ann. Soc. Ent. France, (5) VI, pp. 183-185.
- PEYERIMHOFF, P. DE. 1900. Sur l'application de la loi phylogénique de Brauer. Bull. Soc. Ent. France, LXIX, pp. 219-223.
1900. Sur le valeur phylogénique et le nombre primitif des tubes de Malpighi chez les Coléoptères. Bull. Soc. Ent. France, LXIX, pp. 295-298.
- PLANET, LOUIS. 1891. *Hydrophilus piceus*. Métamorphoses. Le Naturaliste, Paris, (2) XIII, pp. 259-260.
- PORTIER, P. 1911. Recherches physiologique sur les insectes aquatiques. Archiv de Zoologie expérimentale et générale, (5) VIII, p. 89.
- POUJADE, G. A. 1901. Sur l'*Hydrophilus piceus* Linn. Bull. Soc. Ent. France, LXX, pp. 229-230.
1902. *Hydrophilus* habits. Idem, pp. 206, 219, 238.
- REITTER, EDMUND. 1909. Hydrophilidæ, Süßwasserfauna Deutschlands, pp. 51-80.
- RENGEL, C. 1901. Zur Biologie des *Hydrophilus piceus*. Biol. Centralblatt., XXI, pp. 173-182, 209-220.
- REY, CL. 1887. *Ochthebius (Calobius) quadricollis* Muls. Essai d'études sur certaines larves de Coléoptères. Ann. soc. Linn., Lyon, (2) XXXIII, p. 141.
- RILEY, C. V. 1881. Notes on *Hydrophilus triangularis* Say. Amer. Nat., XV, p. 814.
- RUPERTBERGER, MATHIAS. 1880. Biologie der Käfer Europas, pp. 112-115.
1894. Die biologische Literatur über die Käfer Europas von 1880 an mit Nachtragen aus früherer Zeit und einen Larven-Cataloge, pp. 113-115, 279.
- RYE, EDWARD C. 1866. The Necrophaga or Clavicornes, pp. 107-109, Pl. VII, figs. 4-5.
- SAUNDERS, WILLIAM. 1879. *Hydrophilus triangularis*: habits and transformations popularly noticed. Can. Ent., XI, p. 223, Fig. 14.
- SCHLÖDTE, J. C. 1861-1862. De Metamorphosi eleutheratorum Observationes: Bidrag til insekternes udviklings-historie, Part I, pp. 4-11, 17-31, Tab. III-VII; Part VI, pp. 174, 211-221, 225-226, Tab. IX.
- SCHLICK, WILLIAM. 1887. Rearing conditions with *Spercheus emarginatus*. Ent. Meddeldser, I, pp. 26-27.

- SCHWARZ, E. A. 1914. Aquatic beetles, especially *Hydrosapha* in Hot Springs, in Arizona. Proc. Ent. Soc. Wash., XVI, pp. 163-168.
- SCOTT, HUGH. 1913. Coleoptera, Hydrophilidæ. Trans. Linn. Soc. London, XVI, (part 2, No. X), pp. 193-222, Pl. xiv (Fig. 22).
- SHARP, D. 1895. On three new species of Hydrophilidæ. Ent. Month. Mag., XI, pp. 247-250.
1887. Hydrophilidæ. Biol. Centr. Amer., 1882-1887, I, part 2, pp. 53-116, Pls. II-III.
1899. Hydrophilidæ. Cam. Nat. Hist., London, V, pp. 216-219.
- STEIN, FREDERICK. 1847. Die weibliche Geschlechtsorgane der Käfer, Berlin, IV, pp. 33-34, III, d.h.
- VOSS, FREDERICK. 1905. Über den Thorax von *Gryllus domesticus*. Zeit. für wissenschaft., LXXVIII, pp. 290-293.
- WARD, JOHN J. 1914. Some new discoveries in natural history. A tool using insect. Strand Mag., XLVIII, pp. 523-525, Figs. 1-5.
- WESENBERG-LUND, CARL. 1915. Vandkaerer (Hydrophilidæ). Insekstlivet i ferske vande., pp. 270-299, Figs. 223-244.
- WICKHAM, F. H. 1893. *Tropisternus glaber*, metamorphosis. Bull. Lab. Nat. Hist., Iowa, II, pp. 228-341, Pl. ix, figs. 13-15.
1895. On the larvæ and pupæ of *Hydrocharis obtusatus* Say. Ent. News, VI, pp. 168-170, Pl. vi, fig. 1 (6).
- WINTERSTEINER, FRED. 1913. Environment of Hydrophilidæ. Journ. New York Ent. Soc., XXI, pp. 54-55.
- ZAITZEV, PH. A. 1908. Catalogue of Hydrophilidæ. Horæ Soc. Ent. Ross., XXX-VIII, pp. 324-418.
- ZAMBEU, CAPTAIN. 1894. Mœurs et métamorphoses d'insectes. *Hydrophilides*. 5th-6th Mém. Ann. Soc. Linn. de Lyon, (n. ser.) XLI, pp. 132-135; XLII, pp. 25-42.

PLATE I

- Fig. 1. Labium, ventral view. *Hydrophilus obtusatus* larva.
 Fig. 2. Head without appendages, dorsal view.
 Fig. 3. Egg-case. *Hydrobius fuscipes*.
 Fig. 4. Mandible of primitive larva of *Ochthebius* type.
 Fig. 5. Maxilla of specialized type of Hydrophilid larva.
 Fig. 6. Caudal view of open stigmatic atrium. *Hydrophilus obtusatus*.
 Fig. 7. Side view of last three segment of larva. *Hydrous triangularis*.
 Fig. 8. Side view of caudal end of larva with anus protruded. *Hydrobius fuscipes*.
 Fig. 9. Dorsal view of closed stigmatic atrium of larva. *Philydrus nebulosus*.
 Explanation of Lettering on Plate I. Numbers Refer to the Abdominal Segments.

a, anus; ab, abductor muscle; ac, acrocercus; ad, adductor muscle; ai, antennal insertion; ap, anterior piece of mandible; c, condyle; ca, cardo; cp, cap of egg-case; e, lateral expansion of epistoma; ep, egg-case proper; es, epicranial suture; f, frons; fa.s, frontal antennal suture; fe.s, fronto-epistomal suture; fl, filament of egg-case; g, gula; l, ligula; lb.pl, labial palpus; l.d, labro-clypeus; ll, lateral lobe; lm, lacinia mobilis; m, mentum; ma, molar area; mc, mesocercus (true cercus); ml, median lobe; mx.pl, maxillary palpus; oa, ocular area; oc, occipital opening; pc, procercus or process of eighth pleurite; plf, palpifer; plfl, lobe of palpifer; plp, palpiger; pp, posterior piece of mandible; sc, sense-cones; sm, submentum; st, stipes; t, trochantin; tr, trachea.

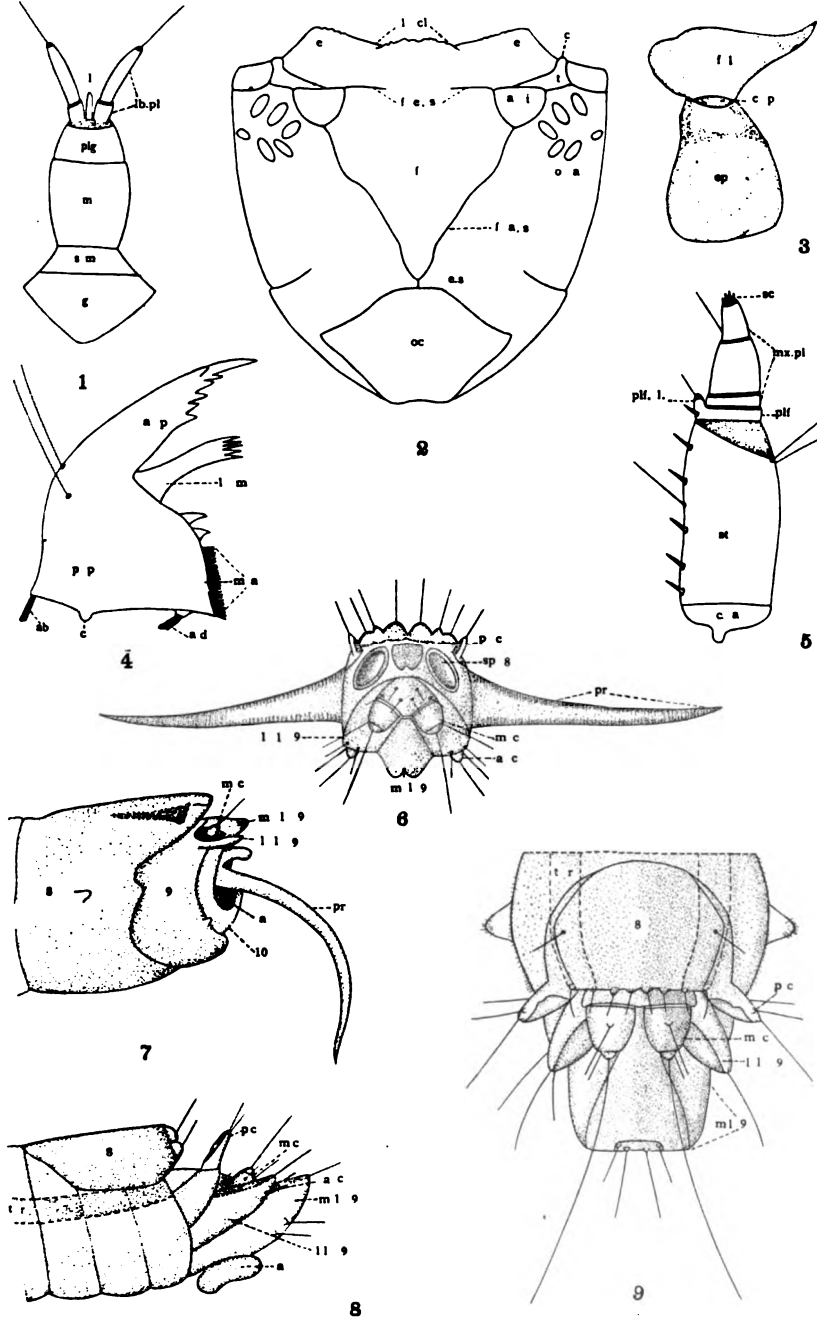


PLATE II

Helophorus lacustris LeConte

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Right antenna, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right maxilla, first stage larva.
- Fig. 5. Head, dorsal view of the anterior part, first stage larva.
- Fig. 6. Right mesothoracic leg, first stage larva.
- Fig. 7. Larva, dorsal view, first stage.
- Fig. 9. Labium, dorsal view, first stage larva.
- Fig. 10. Egg-case.

Helophorus sp. ?

- Fig. 8. Egg-case.

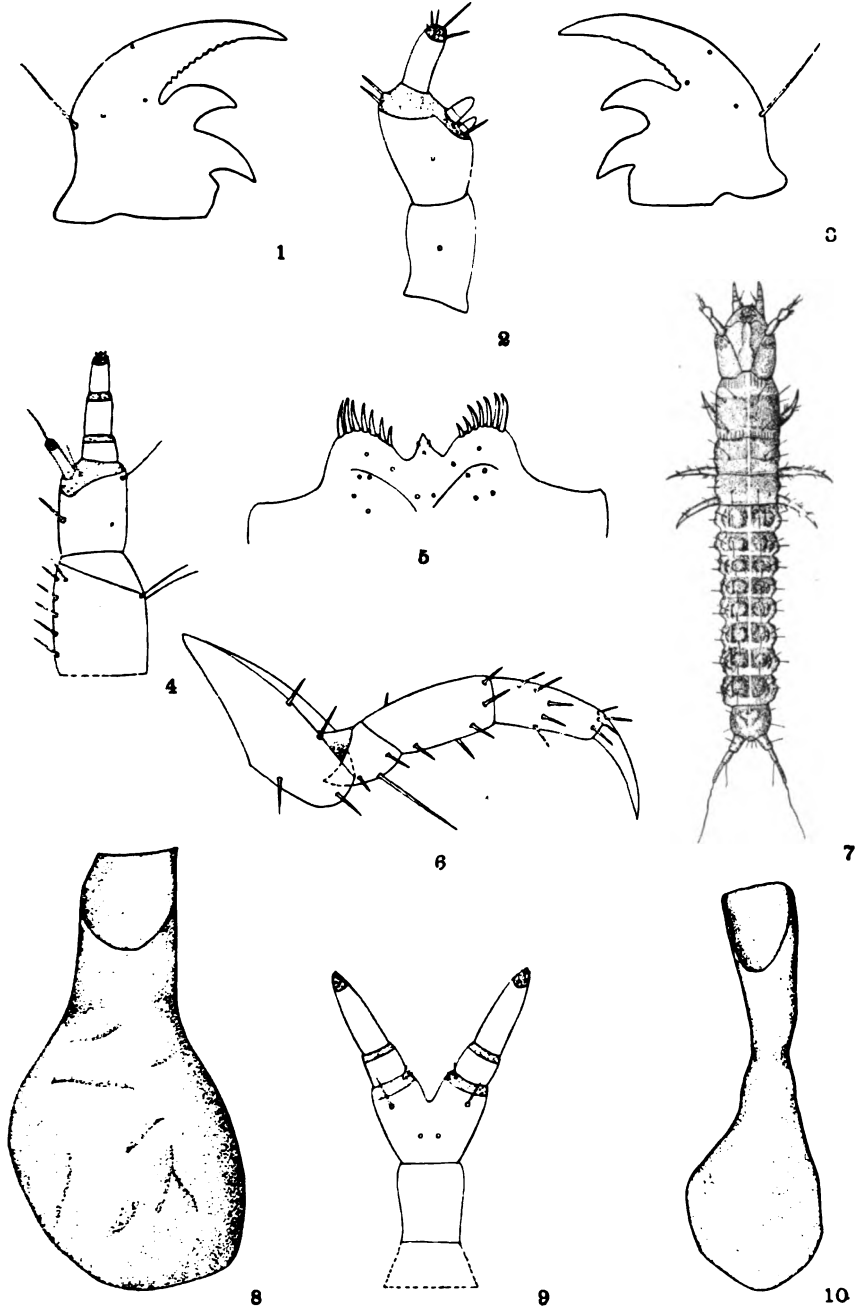
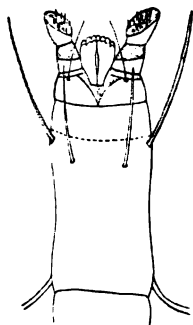


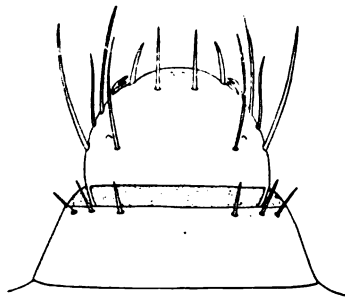
PLATE III

Ochthebius tuberculatus LeConte

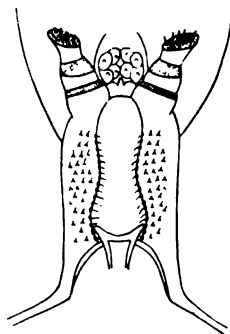
- Fig. 1. Labium, ventral view, first stage larva.
- Fig. 2. Labrum and clypeus, dorsal view, first stage larva.
- Fig. 3. Labium, dorsal view, first stage larva.
- Fig. 4. Tip of right mandible, ventral view, first stage larva.
- Fig. 5. Tip of left mandible, ventral view, first stage larva.
- Fig. 6. Right maxilla, first stage larva
- Fig. 7. Right mesothoracic leg, first stage larva.
- Fig. 8. Right mandible, first stage larva.
- Fig. 9. Caudal end of the anal segment, side view, first stage larva.
- Fig. 10. Egg with loose covering of silk.
- Fig. 11. Right antenna, first stage larva.
- Fig. 12. Larva, dorsal view, first stage.



1



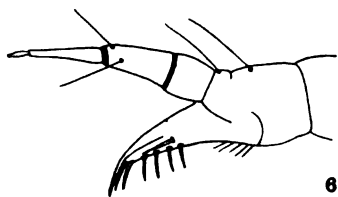
2



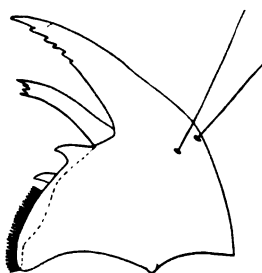
3



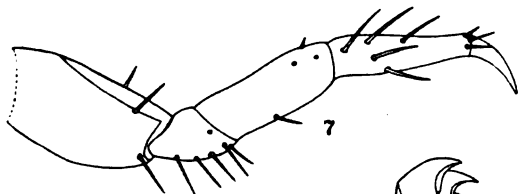
4



5



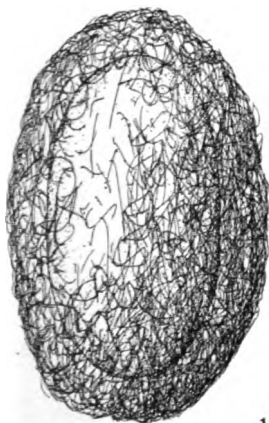
6



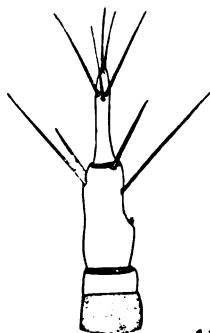
7



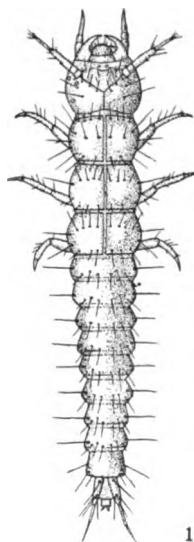
8



9



10

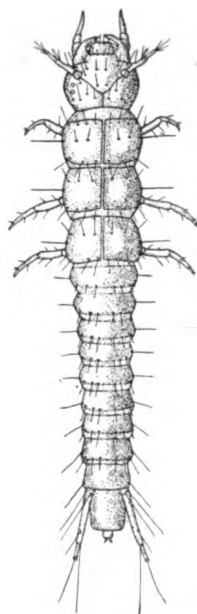
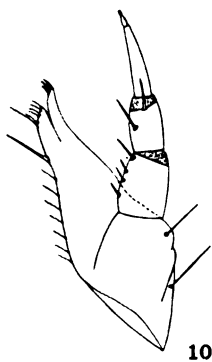
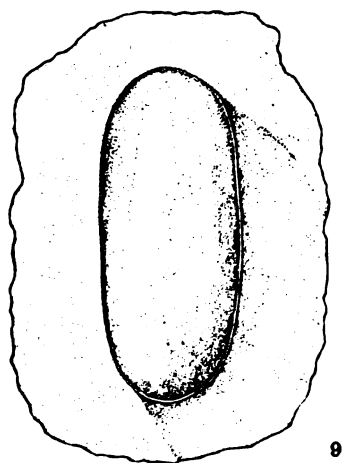
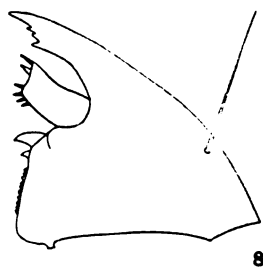
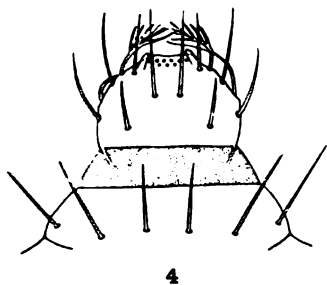
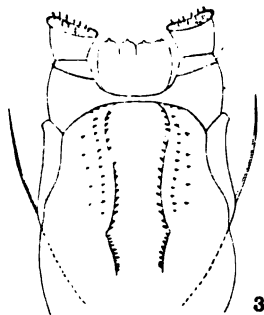
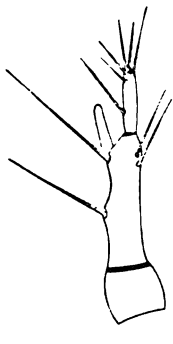
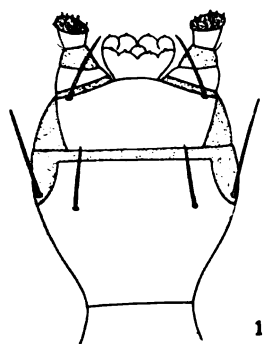


11

PLATE IV

Hydræna pennsylvanica Kiesenwetter

- Fig. 1. Labium, ventral view, first stage larva.
- Fig. 2. Right antenna, first stage larva.
- Fig. 3. Labium, dorsal view, first stage larva.
- Fig. 4. Labrum and clypeus, dorsal view, first stage larva.
- Fig. 5. Tip of right mandible, ventral view, first stage larva.
- Fig. 6. Tip of left mandible, ventral view, first stage larva.
- Fig. 7. Right mesothoracic leg, first stage larva.
- Fig. 8. Right mandible, first stage larva.
- Fig. 9. Egg-case, showing the single egg within.
- Fig. 10. Right maxilla, first stage larva.
- Fig. 11. First stage larva, dorsal view.



11

PLATE V

Hydrochous squamifer LeConte

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Ventral side of head with mouth-parts removed except labium. First stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right maxilla, first stage larva.
- Fig. 5. Anterior region of head, dorsal view, first stage larva.
- Fig. 6. Right antenna, first stage larva.
- Fig. 7. First stage larva, dorsal view.
- Fig. 8. Right mesothoracic leg, first stage larva.
- Fig. 9. Egg-case, enclosing the single egg.

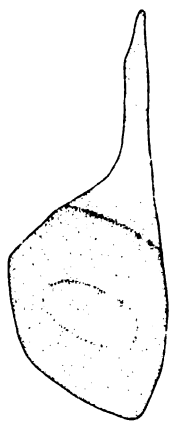
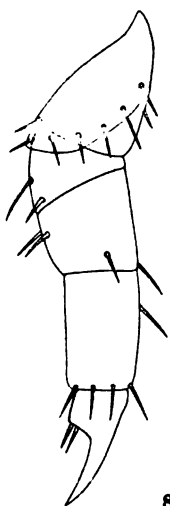
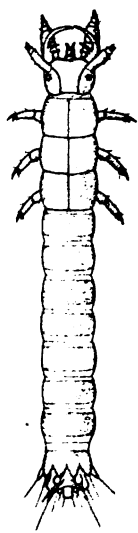
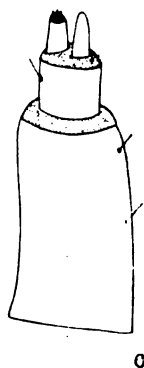
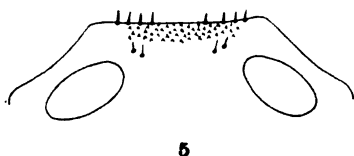
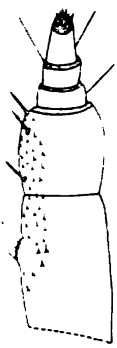
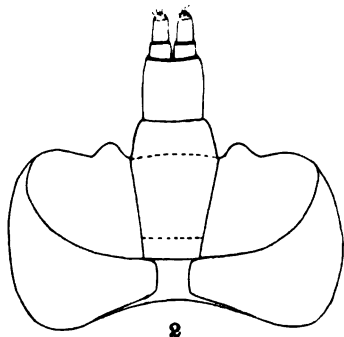
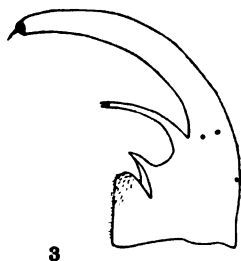
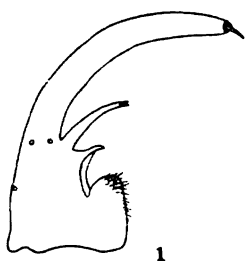
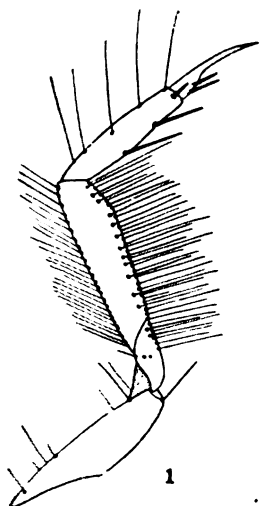


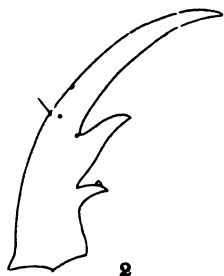
PLATE VI

Hydrophilus obtusatus Say

- Fig. 1. Right mesothoracic leg, first stage larva.
- Fig. 2. Left mandible, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Egg-case with leaf wrapped about it.
- Fig. 5. Right maxilla, first stage larva.
- Fig. 6. Labium, dorsal view, first stage larva.
- Fig. 7. Anterior region of head, dorsal view, first stage larva.
- Fig. 8. Full-grown larva, dorsal view.
- Fig. 9. Right antenna, first stage larva.
- Fig. 10. Egg-case enlarged and without leaf.



4



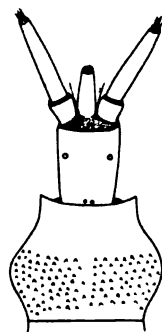
2



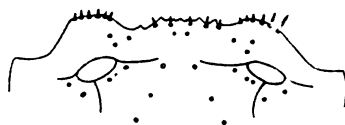
3



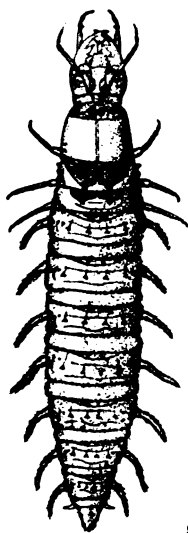
5



6



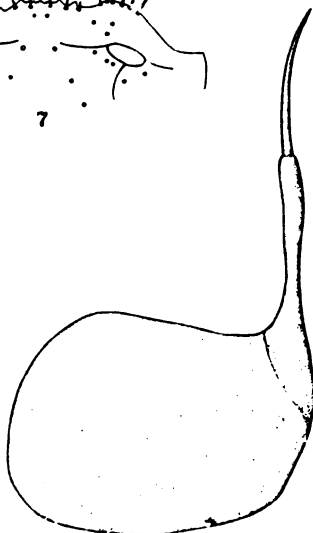
7



8



9



10

PLATE VII

Tropisternus glaber Herbst

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Right mandible, first stage larva.
- Fig. 3. Right maxilla, first stage larva.
- Fig. 4. Right mesothoracic leg, first stage larva.
- Fig. 5. Right antenna, first stage larva.
- Fig. 6. Anterior region of head, first stage larva.
- Fig. 7. Egg-case, side view.
- Fig. 8. Labium, dorsal view, first stage larva.
- Fig. 9. Full-grown larva, dorsal view.

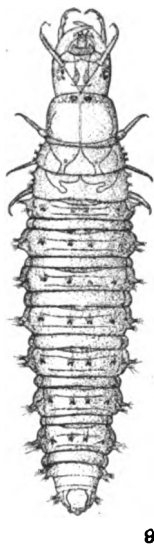
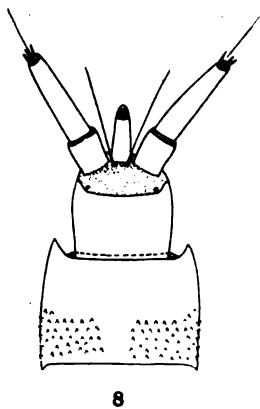
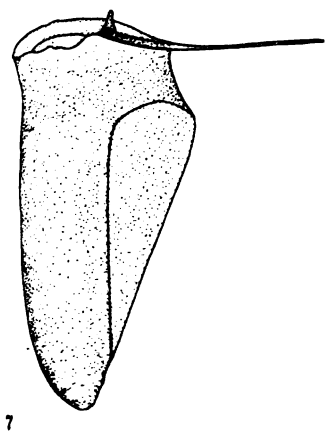
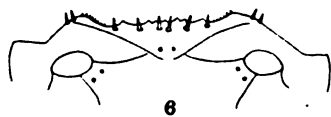
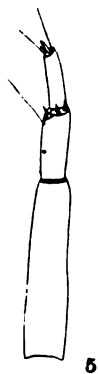
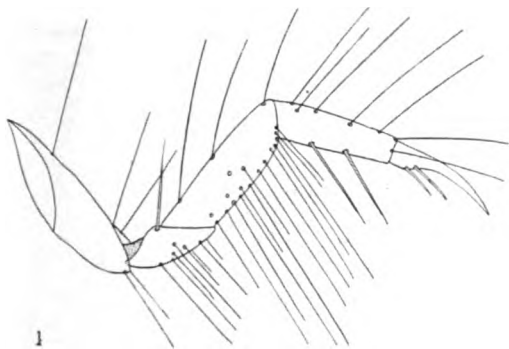
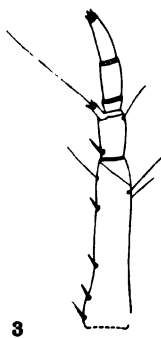
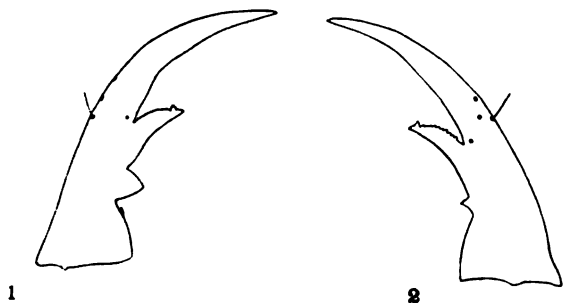
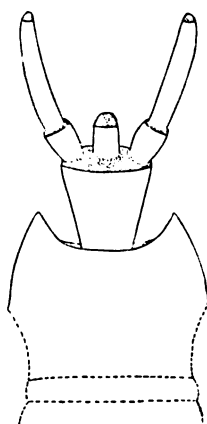
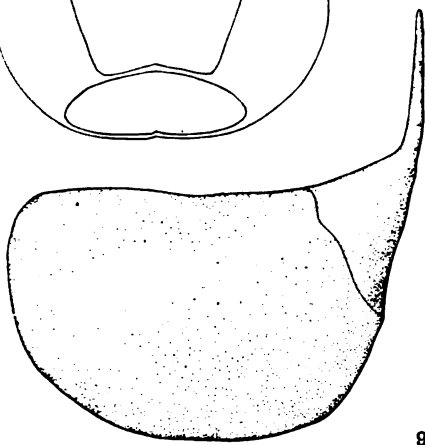
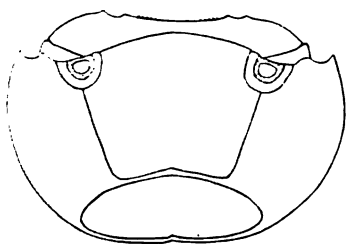
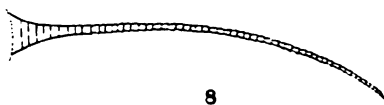
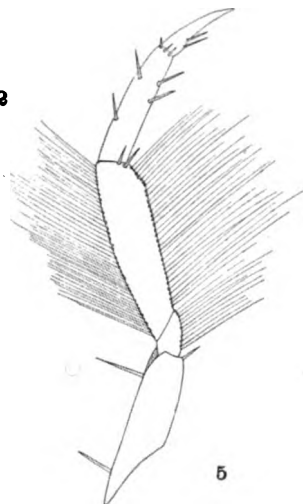
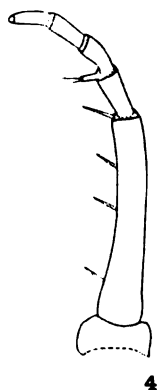
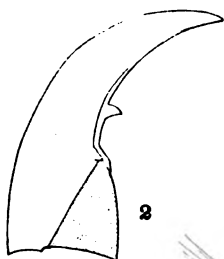
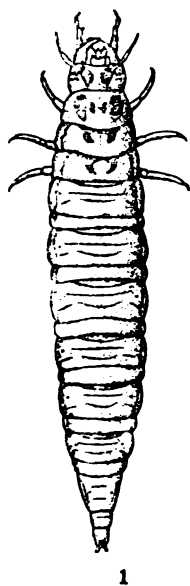


PLATE VIII

Hydrous triangularis Say

- Fig. 1. Full-grown larva, dorsal view.
- Fig. 2. Left mandible, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right maxilla, first stage larva.
- Fig. 5. Right mesothoracic leg, first stage larva.
- Fig. 6. Right antenna, first stage larva.
- Fig. 7. Head without appendages, dorsal view, first stage larva.
- Fig. 8. Motory stylus of pupa.
- Fig. 9. Egg-case.
- Fig. 10. Labium, dorsal view, first stage larva.



10

PLATE IX

Laccobius agilis Randall

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Extremity of pupa, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right antenna, first stage larva.
- Fig. 5. Right mesothoracic leg, first stage larva.
- Fig. 6. Full-grown larva.
- Fig. 7. Right maxilla, first stage larva.
- Fig. 8. Anterior region of the head from above, first stage larva.
- Fig. 9. Egg-case. Brown variety.
- Fig. 10. Labium, dorsal view, first stage larva.
- Fig. 11. Egg-case, showing exit hole of larvæ. Silver or light gray variety.

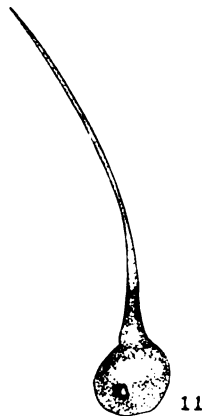
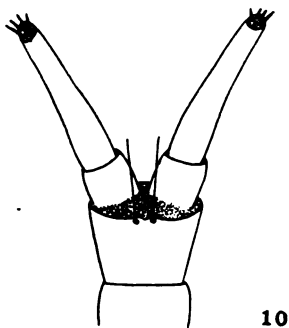
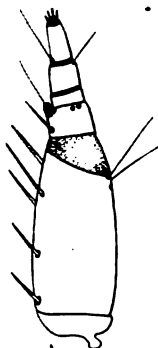
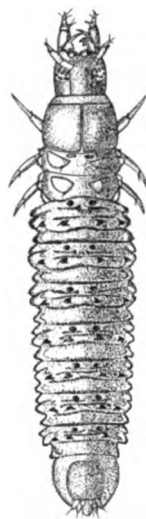
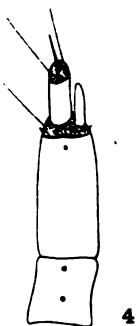
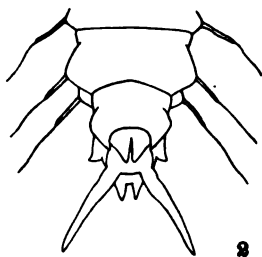


PLATE X

Berosus peregrinus Herbst

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Right mandible, first stage larva.
- Fig. 3. Right maxilla, first stage larva.
- Fig. 4. Right mesothoracic leg, first stage larva.
- Fig. 5. Pleural lobe of thorax, first stage larva.
- Fig. 6. Right antenna, first stage larva.
- Fig. 7. Anterior part of head, dorsal view, first stage larva.
- Fig. 8. Full-grown larva, dorsal view.
- Fig. 9. Labium, dorsal view, first stage larva.
- Fig. 10. Egg-case, side view.
- Fig. 11. Egg-case, front view.

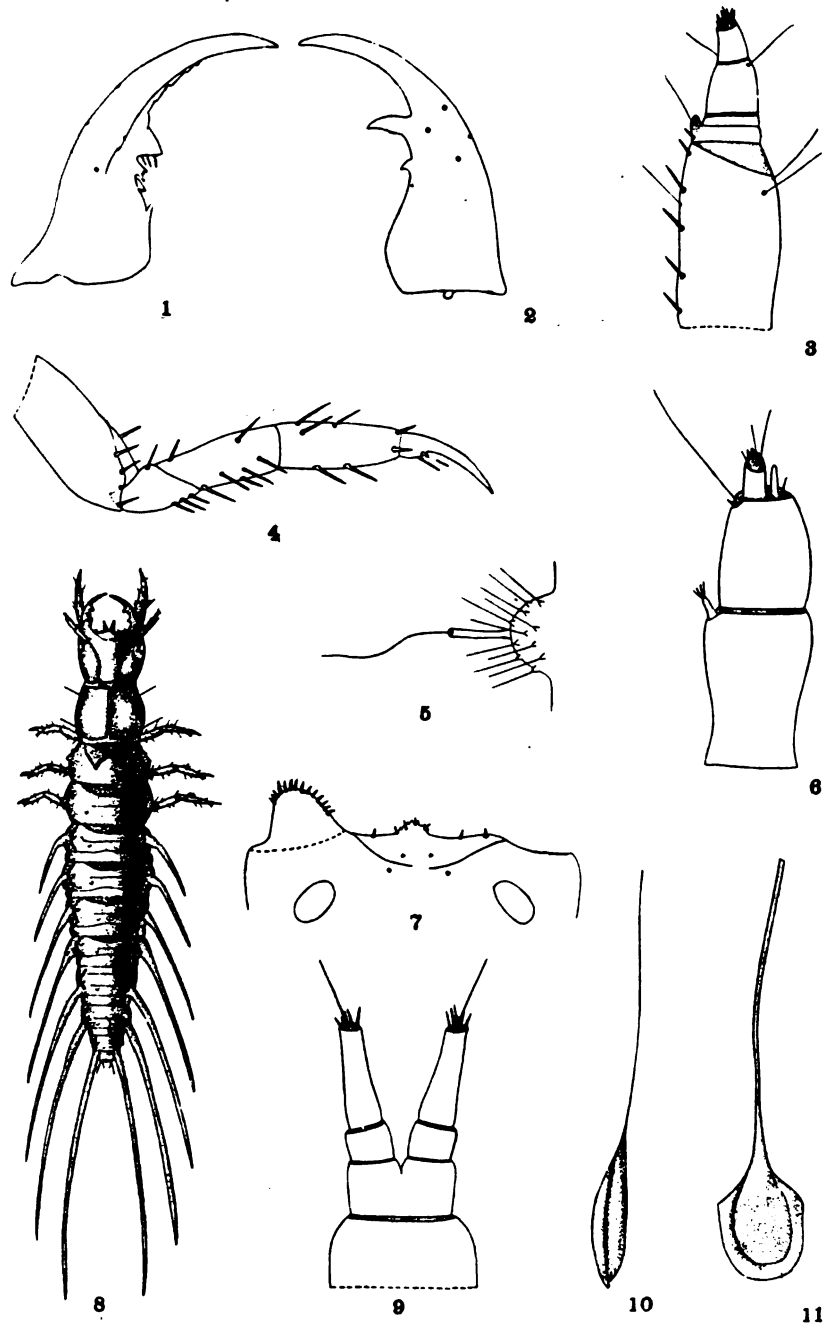


PLATE XI

Hydrobius globosus Say

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Labium, dorsal view, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right mesothoracic leg, first stage larva.
- Fig. 5. Right maxilla, first stage larva.
- Fig. 6. Anterior region of head, dorsal view, first stage larva.
- Fig. 7. Right antenna, first stage larva.
- Fig. 8. Egg-case.
- Fig. 9. Full-grown larva, dorsal view.

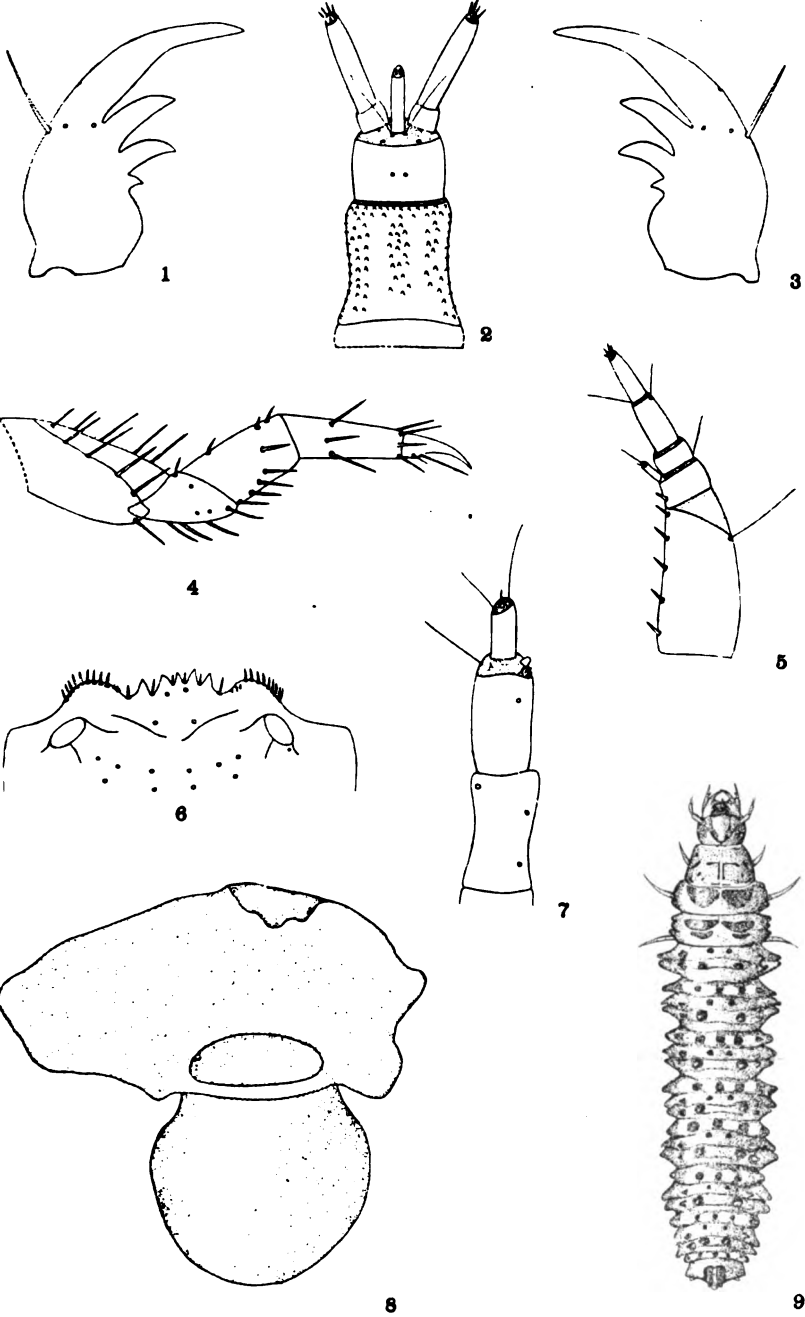


PLATE XII

Cymbiodyta fimbriata Melsheimer

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Labium, dorsal view, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Anterior region of head, dorsal view, first stage larva.
- Fig. 5. Right antenna, first stage larva.
- Fig. 6. Right mesothoracic leg, first stage larva.
- Fig. 7. Full-grown larva, dorsal view.
- Fig. 8. Pupa, ventral view of caudal end.
- Fig. 9. Right maxilla, first stage larva.

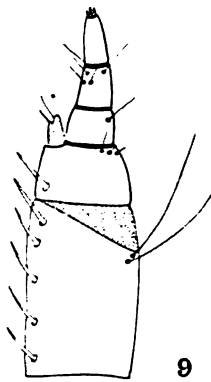
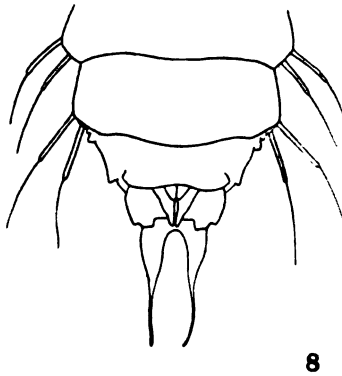
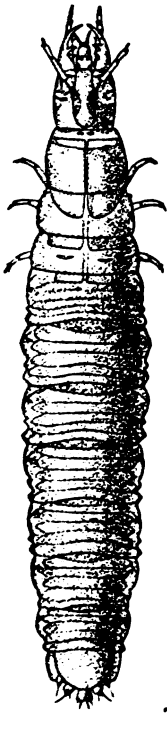
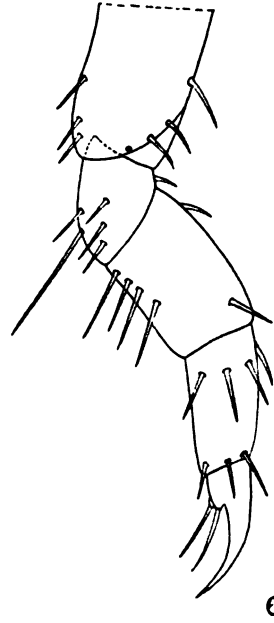
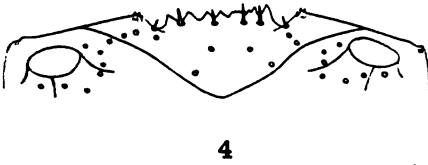
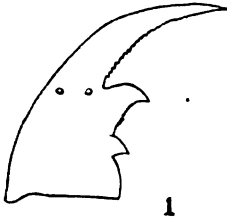
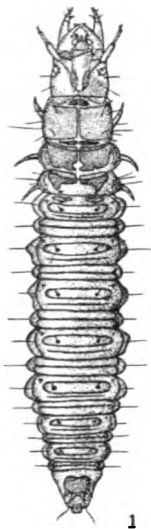


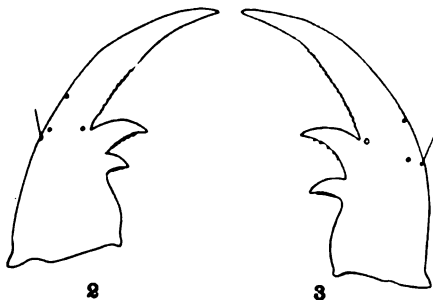
PLATE XIII

Helochaeres maculicollis Mulsant

- Fig. 1. Full-grown larva, dorsal view.
- Fig. 2. Left mandible, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right antenna, first stage larva.
- Fig. 5. Anterior region of head, dorsal view, first stage larva.
- Fig. 6. Right mesothoracic leg, first stage larva.
- Fig. 7. Right maxilla, first stage larva.
- Fig. 8. Labium, dorsal view, first stage larva.
- Fig. 9. Egg-case, ventral view.



1



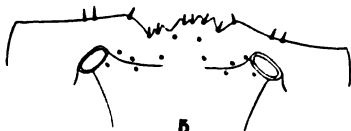
2



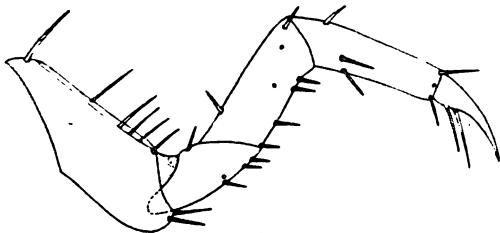
3



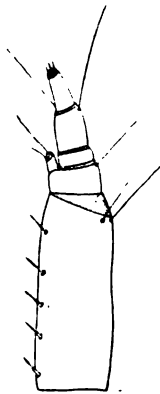
4



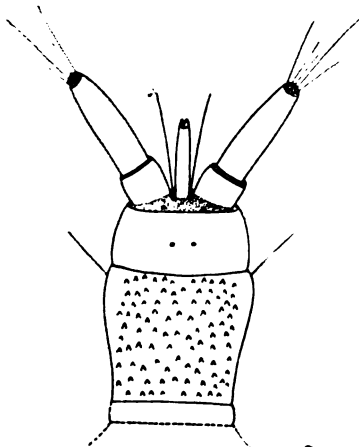
5



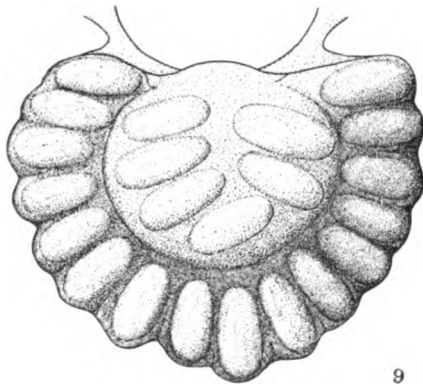
6



7



8



9

PLATE XIV

Philydrus perplexus LeConte

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Labium, dorsal view, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Labium, ventral view, first stage larva.
- Fig. 5. Right mesothoracic leg, first stage larva.
- Fig. 6. Right maxilla, first stage larva.
- Fig. 7. Right antenna, first stage larva.
- Fig. 8. Anterior region of head, dorsal view, first stage larva.
- Fig. 9. Full-grown larva, dorsal view.
- Fig. 10. Egg-case.

Philydrus ochraceus

- Fig. 11. Egg-case.

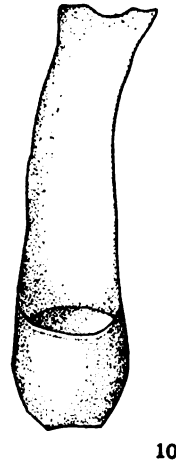
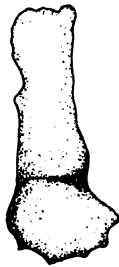
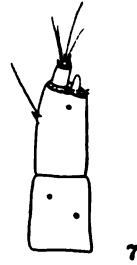
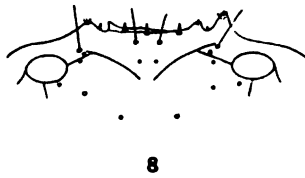
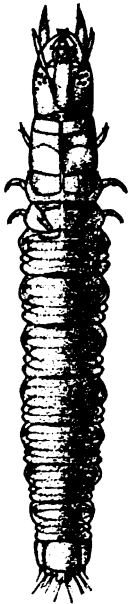
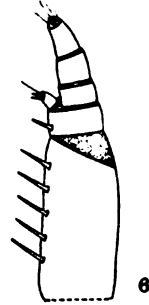
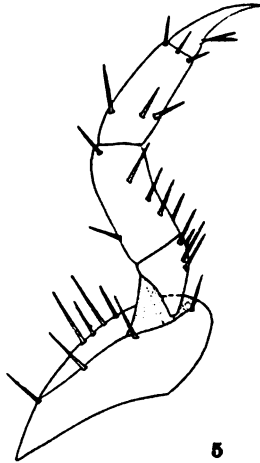
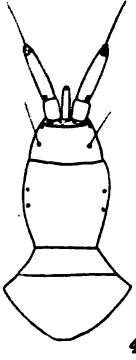
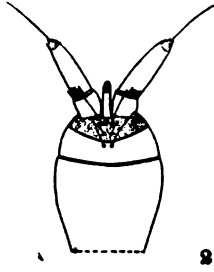


PLATE XV

Ancæna infuscata Motschulsky

- Fig. 1. Left mandible of first stage larva.
- Fig. 2. Labium, dorsal view, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right mesothoracic leg, first stage larva.
- Fig. 5. Right maxilla, first stage larva.
- Fig. 6. Anterior margin of head, dorsal view, first stage larva.
- Fig. 7. Full-grown larva, dorsal view.
- Fig. 8. Right antenna, first stage larva.
- Fig. 9. Egg-case.

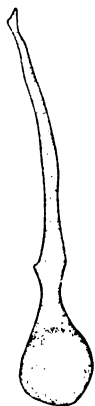
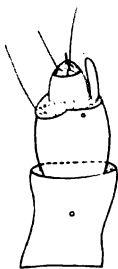
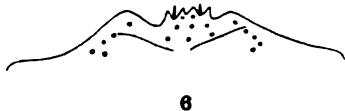
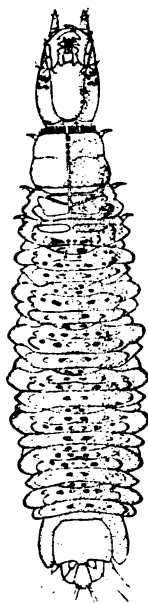
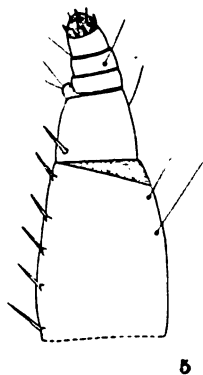
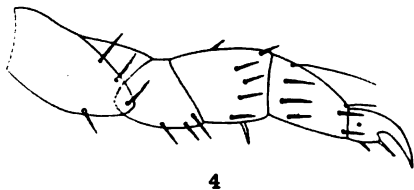
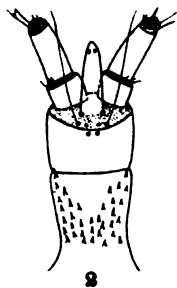
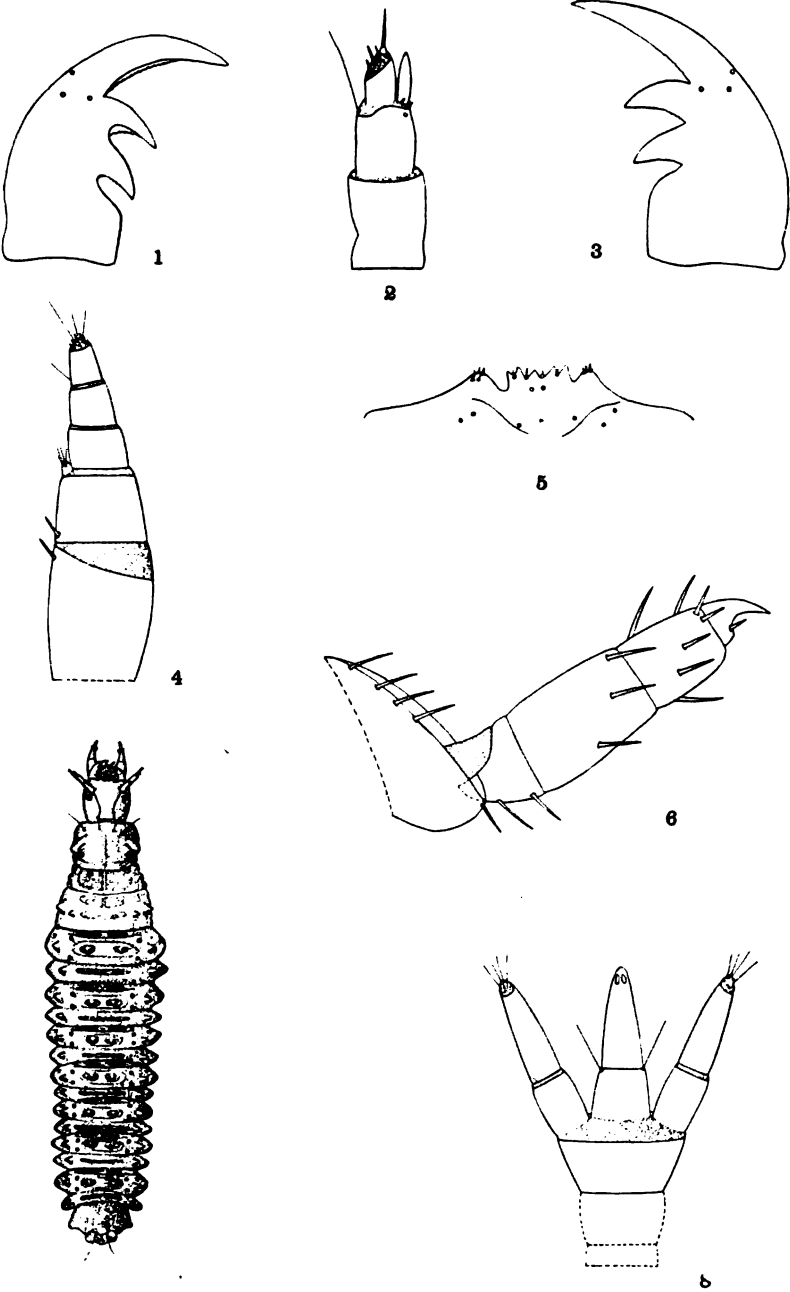


PLATE XVI

Paracymus subcupreus Say

- Fig. 1. Left mandible, first stage larva.
- Fig. 2. Right antenna, first stage larva.
- Fig. 3. Right mandible, first stage larva.
- Fig. 4. Right maxilla, first stage larva.
- Fig. 5. Anterior region of head, dorsal view, first stage larva.
- Fig. 6. Right mesothoracic leg, first stage larva.
- Fig. 7. Full-grown larva, dorsal view.
- Fig. 8. Labium, dorsal view, first stage larva.



**Article II.—STUDIES IN COMPARATIVE MYOLOGY AND
OSTEOLOGY: NO. IV.—A REVIEW OF THE EVOLUTION
OF THE LACRYMAL BONE OF VERTEBRATES WITH
SPECIAL REFERENCE TO THAT OF MAMMALS**

BY WILLIAM K. GREGORY

PLATE XVII

TABLE OF CONTENTS

ERRATUM AND ADDENDUM

Page 182, Fig. 143. The bone marked *l* is not the lacrymal, but the inner orbital wall of the maxilla. The lacrymal of *Manatus*, as shown by Hartlaub,¹ is a variable and often vestigial element, forming a delicate plate on the anterior border of the orbit and in contact with frontal, maxilla, and jugal.

Page 180. A recently prepared specimen of *Mærittherium andrewsi* (Amer. Mus. No. 13432) shows certain of the sutures remarkably well and confirms the determination of the sutures by Dr. Andrews, so far as shown in Fig. 142. The nasals separated the frontals from the premaxillæ and were in contact with the maxillæ. The lacrymal *if present* cannot be clearly distinguished from the maxilla, which appears to have formed the floor and anterior part of the orbit. The maxilla bears a low tubercle for the ligamentum tarsale. A small hole in the maxilla in front of the orbit may possibly represent the naso-lacrymal duct.

¹1886, Beiträge zur Kenntnis der Manatus Arten. Zool. Jahrb., I, pp. 1-112, Pls. i-iv. (Die Thränenbeine, pp. 81-86 and Pl. iv.)

Amniota (Mammalia).....	166
Tæniodonta (Ganodonta).....	166
Edentata (Xenarthra).....	168
Pholidota.....	171
Tubulidentata.....	171
Tillodontia.....	171
Rodentia.....	172
Lagomorpha.....	174
Condylarthra.....	176



**Article II.—STUDIES IN COMPARATIVE MYOLOGY AND
OSTEOLOGY: NO. IV.—A REVIEW OF THE EVOLUTION
OF THE LACRYMAL BONE OF VERTEBRATES WITH
SPECIAL REFERENCE TO THAT OF MAMMALS**

By WILLIAM K. GREGORY

PLATE XVII

TABLE OF CONTENTS

	PAGE
INTRODUCTION.....	97
The Lacrymal Bone in Comparative Anatomy and Palæontology.....	97
Origin and Scope of the Present Work.....	100
Synopsis of the Classification of the Vertebrates Adopted in this Work....	101
Classification, According to Function and Position, of the Skull Elements Illustrated in this Work, with Abbreviations used in the Figures.....	105
ANALYSIS AND CLASSIFICATION OF TYPICAL CONDITIONS OF THE LACRYMAL AND SURROUNDING PARTS IN REPTILES, BIRDS, AND MAMMALS.....	107
ORIGIN AND EVOLUTION OF THE LACRYMAL IN THE LOWER VERTEBRATES.....	111
Fishes.....	111
Amphibia.....	114
Primitive Reptiles.....	119
Diapsid Reptiles.....	123
Birds.....	128
Rhynchocephalida, Parapsida.....	129
THE LACRYMAL REGION IN THE THERAPSID REPTILES.....	131
THE TRANSITION FROM REPTILIAN TO MAMMALIAN CONDITIONS.....	135
THE LACRYMAL REGION OF ALLOTHERIA, MONOTREMES, AND MARSUPIALS...	137
Allotheria.....	137
Monotremata.....	137
Marsupialia.....	137
THE LACRYMAL REGION IN THE PLACENTAL ORDERS OF THE PALEOCENE, EOCENE, AND LATER EPOCHS.....	145
Creodonta.....	145
Fissipedia.....	148
Pinnipedia.....	156
Cetacea.....	158
Insectivora (Lipotyphla).....	163
Tæniodonta (Ganodonta).....	166
Edentata (Xenarthra).....	168
Pholidota.....	171
Tubulidentata.....	171
Tillodontia.....	171
Rodentia.....	172
Lagomorpha.....	174
Condylarthra.....	176

Litopterna.....	176
Entelonychia.....	177
Astrapotheria.....	177
Toxodontia.....	178
Typotheria.....	178
Amblypoda.....	180
Proboscidea.....	180
Sirenia.....	184
Embrithopoda.....	184
Hyracoidea.....	184
Artiodactyla.....	186
Perissodactyla.....	193
Menotyphla.....	199
Dermoptera.....	200
Chiroptera.....	200
Primates.....	200
SUMMARY OF THE EVOLUTION OF THE LACRYMAL BONE.....	212
THE LACRYMAL PROBLEM IN ITS PHYLETIC AND TAXONOMIC ASPECTS: A PHYLOGENETIC REVIEW OF THE VERBETRATES.....	217
REFERENCES TO LITERATURE.....	250
Addendum: Wa son (1913) on the Naso-lacrymal Duct of <i>Nythosaurus</i> and <i>Diademodon</i>	263

INTRODUCTION

THE LACRYMAL BONE IN COMPARATIVE ANATOMY AND PALÆONTOLOGY

Cuvier, in the '*Histoire naturelle des Poissons*' (by Cuvier and Valenciennes, 1828), gives a brief résumé (pp. 307-516) of early work on the osteology of the skull of fishes, the subject from which the lacrymal problem later arose. He states that before 1798 very little had been written concerning the bones of the head of fishes. In his '*Leçons d'Anatomie*' (1798) he had said little about the composition of the brain-case but had dealt more in detail with the bones of the face, although still very incompletely. Recognizing the great need for more facts, he had gradually assembled an extensive osteological collection, which had been the basis for his own subsequent researches as well as for those of others.

In 1807 Oken put forth his celebrated theory of the vertebral nature of the skull, which, although exceedingly crude, stimulated a vast amount of comparative anatomical research. Perhaps even more fruitful was the elder Geoffroy's idea of the unity of type in the animal kingdom.

Studies by Geoffroy (1807) and by Cuvier (1812) on the skull of recent and fossil crocodilians furnished, as it were, an intermediate type between man on the one hand and fish on the other, which facilitated the comparison of the two extremes. Cuvier's system of names for the elements of the skull of vertebrates was first published in 1812 and further developed in 1814 and 1817.

In 1815 Spix homologized Cuvier's "*frontaux antérieurs*" of fishes with the lacrymal of man, a view which was also held by Geoffroy. Cuvier (1828, p. 314) in criticising this view remarks: "*Ces os ('frontaux antérieurs') existent dans les crocodiles, dans les tortues, etc., à côté des vrais lacrymaux caractérisés pour tels, et ne peuvent leur être substitués.*"

Thus Cuvier recognized that the lacrymals of crocodiles are homologous with those of man. But, with regard to the "*frontaux antérieurs*," it is now known that these elements (prefrontals) in crocodiles, turtles, etc., are not homologous with the similarly appearing bones in fishes, since the true prefrontals are derm bones while the "*frontaux antérieurs*" of fishes are underlying endocranial elements, ossifications of the lateral, or "*aliethmoid*" wings of the nasal capsules. On this account W. K. Parker (1872) called the "*frontaux antérieurs*" of fishes "*lateral ethmoids*" and T. J. Parker (1893) named them "*parethmoids*."

In 1818 Carus sought to identify the human lacrymal with the first suborbital bone of fishes (Cuvier's "premier sous-orbitaire"). As to this homology Cuvier says (1828, p. 337): "le premier *sous-orbitaire* . . . est articulé a une facette de l'apophyse inférieurs externe du frontal antérieur; ce qui pourrait le faire regarder comme analogue de lacrymal." But immediately below in a footnote he says: "C'est l'adorbital ou portion orbitaire du maxillaire de M. Geoffroy. MM. Spix, Bojanus, Bakker et Meckel le rapportent, ainsi que les suivans, au *jugal*. Pour M. Carus, c'est le lacrymal. Ce qui me fait considérer cet appareil comme différent de ceux des autres vertébrés, c'est qu'il recouvre les muscles, au lieu de leur donner attachment." Thus, Cuvier, as well as others of his contemporaries, apparently recognized more or less clearly that the series of suborbital bones in fishes bore some resemblance to the series comprising the bones now called the prefrontal, lacrymal, jugal, and postorbital in reptiles; but, with commendable caution, he doubted the implied homologies. While not sufficiently explicit, his objection probably meant that in the fishes the suborbital series lies altogether outside of the jaw and face muscles, while in mammals the jugal and lacrymal are more or less covered by muscles, the jugal giving attachment to the masseter. He apparently did not take into consideration the probability that in the higher vertebrates, especially the mammals, the dermal bones around the eye have sunk deeply beneath the surface and that the muscles have gained new attachments.

In 1843 Owen, in his table entitled "Synonyms of the Bones of the Head of Fishes according to their Special Homologies," definitely attributes to Cuvier the view that the lacrymal is homologous with the first suborbital of fishes. Owen himself adopted it and so, apparently, did all other authors until quite recent times.

Apparently the first to doubt the correctness of this "Cuvierian concept" was E. Gaupp (1910, p. 535), who in 1898, in describing the development of the lizard skull, raised the question whether the so-called lacrymal of the lizard is really the homologue of the mammalian lacrymal. In 1910 Gaupp developed this idea in an important paper entitled 'Das Lacrimale des Menschen und der Säuger und seine morphologische Bedeutung.' After reviewing the topographic relations of the so-called prefrontal and lacrymal bones of recent Sauropsida to the nasal capsules and to the ductus naso-lacrymalis, with special reference to conditions in *Lacerta*, he concluded that the evidence pointed to the non-homology of the so-called lacrymal of reptiles with the true lacrymal of mammals,

which appeared to him to be the homologue of the reptilian prefrontal. He therefore proposed to name the reptilian prefrontal "os lacrimale," while for the so-called lacrymal of reptiles he suggested the name "adlacrimale."

Meanwhile (1904-1905) O. Jaekel had reached substantially similar conclusions upon quite different grounds. In describing the skull of *Udenodon pusillus*, a very small anomodont from South Africa, this author applied the name "lacrymalia" to the bones that were located at the anterosuperior quarter of the orbits, and which had by other authors been named prefrontals. He states, however, that certain breaks in this specimen could not be clearly distinguished from zigzag sutures and that there might be two prefrontal elements. However, having recognized the apparent similarity of the dorsal element on the one hand to the lacrymal of mammals, and on the other hand to the prefrontal of reptiles, Jaekel in 1905 ("Ueber den Schädelbau der Nothosauriden") published a series of figures of skulls, including *Trematosaurus*, *Sphenodon*, *Placochelys*, and *Simosaurus*, in which he applied the designation *L* ("lacrymale") to the element formerly called prefrontal, while for the element formerly named "lachrymal," he proposed the name *postnasal*. Thus, Gaupp and Jaekel were in agreement as to the homology of the reptilian prefrontal with the mammalian lacrymal, but they applied different names to the lower element, Jaekel calling it "postnasale" and Gaupp "adlacrimale."

Although adopted without question by von Huene (1911, p. 43) and by Wiman (1917),¹ the Gaupp-Jaekel view of the homology of the lacrymal of mammals with the reptilian prefrontal has not been adopted by Broili, Case, Williston, Broom, Watson,² Houghton, and other authors who have described Permian reptiles in recent years. In opposition to this view in 1912 and '13 I called attention to the fact that Gaupp and Jaekel had neglected to take into consideration the conditions of the preorbital elements of the Cynodontia, the very reptiles which, above all others, might be expected to throw light on this question, and in which, as will be more fully shown below, the lower preorbital element has every appearance of homology with the lacrymal of mammals. In the same papers it was suggested that the resemblance of the prefrontal of *Lacerta* to the lacrymal of mammals was a convergence phenomenon by which Gaupp had been deceived. This topic is further considered on pages 131 and 135 of the present paper.

¹Also by Abel in his 'Die Stämme der Wirbeltiere,' 1919.

²See addendum, p. 263.

In 1864 Nathusius showed that the lacrymal bone had a certain diagnostic value in distinguishing the different races of the genus *Sus*. This side of the subject, with special reference to the ruminants, was developed by Kober (1880) and more fully by Knotternus Meyer (1907).

In 1901 Forsyth Major published a very systematic and minute study of the lacrymal region of primates with important results which are discussed below.

From the viewpoint of anthropotomy, Le Double (1900) has monographed the numerous variations of the lacrymal region of man; while many investigators (e.g., Hoffman, 1882; Born, 1876; Gaupp, 1910; Tüffers, 1913) have worked out the morphology of the naso-lacrymal duct.

ORIGIN AND SCOPE OF THE PRESENT WORK

The present investigation has partly grown out of a difference of opinion between Dr. J. L. Wortman and myself concerning the probable course of evolution of the lacrymal bone in Primates. As will be shown below (page 207), this eminent anatomist and palæontologist assumes certain conditions of the lacrymal region to be primitive in placental mammals which I am compelled to regard as secondary. In seeking collateral evidence on this matter, before finishing the recently published work on the Eocene Primates of the *Notharctus* group, I was led into a somewhat extended review of the morphology and probable history of the lacrymal in all the orders of mammals. This line of study naturally connected itself with the history of the facial bones in recent and extinct reptiles, amphibians, and fishes, a subject to which I had already devoted considerable attention and to which in recent years the labor of those who have described Palæozoic vertebrates of all classes has brought such substantial evidence that most of the skull elements, both dermal and endocranial, can now be clearly followed throughout the Tetrapoda. It thus seemed worth while to bring all these observations and deductions together into a single paper and to prepare a special series of drawings illustrating the general history of the facial bones from fish to man. These drawings have been prepared, very conscientiously and skilfully, by Mr. Erwin S. Christman and Mrs. Elizabeth M. Fulda, under my constant direction.

SYNOPSIS OF THE CLASSIFICATION OF THE VERTEBRATES ADOPTED IN THIS WORK

Phylum CHORDATA

Subphylum VERTEBRATA

Superclass AGNATHA

Class OSTRACODERMI

Ostracoderms

Class ARTHRODIRA

Arthrodires

Class CYCLOSTOMATA

Cyclostomes

Superclass CHONDRICHTHYES

Class ELASMOBRANCHII

Sharks, chimæroids

Superclass OSTEICHTHYES

Class DIPNOI (DIPNEUSTI)

Lung fishes

Class CROSSOPTERYGII

Crossopterygians

Order Rhipidistia (Osteolepida)

Osteolepida, etc.

Order Actinistia

Cœlacanth

Order Cladistia

Polypterus, *Calamoichthys*

Class ACTINOPTERYGII

Actinopterygians

Order Chondrostei

Old ganoids

Suborder Palæoniscoidei

Suborder Acipenseroidei

Order Holostei

New ganoids

Order Isospondyli

Old teleosts

Order Ostariophysi

Order Haplomi

Intermediate teleosts

Order Iniomi, etc.

Order Acanthopterygii

New teleosts

Superclass TETRAPODA

Class AMPHIBIA¹

Subclass STEGOCEPHALIA

Order Phyllospodyli

Branchiosaurs

Order Lepospondyli

Microsaurs, etc.

Order Temnospondyli

Temnospondyls

Suborder Embolomeri

Cricotus, etc.

Suborder Rhachitomi

Eryops, etc.

Suborder Stereospondyli

Mastodonsaurus, etc.

Subclass EUAMPHIBIA (BATRACHIA)

Order Gymnophiona (= Apoda)

Cæcilians

Order Urodela (= Caudata)

Salamanders, etc.

Order Anura (= Salientia)

Frogs and Toads

Class REPTILIA²

Series A ANAPSIDA

Order Cotylosauria

Suborder Seymouriamorpha

Seymouriidae, ?Sauravidae

Suborder Diadectomorpha

Diadectidae, Pariasauridae,

¹For a recent classification of the early Amphibia see Watson, D.M.S., 1917, Proc. Zool. Soc. London, pp. 167-170.

²For recent classifications of the Reptilia, see Williston, 1917, Journ. Geol., XXV, pp. 411-421; Watson, *op. cit.*, pp. 171-183.

- Procolophonidæ
 - Suborder Captorhinomorpha Limnoscelidæ, Captorhinidæ,
Pariotichidæ, Gymnarthridæ, Pantyl-
idæ
 - Order Chelonia
 - Suborder Eunotosauria
 - Suborder Pleurodira
 - Suborder Cryptodira
 - Suborder Atheca
 - Suborder Trionychia
- Series B SYNAPSIDA
 - Order Pelycosauria (= Theromorpha)
 - Suborder Caseasauria Caseidæ
 - Suborder Pelycosauria (S. S.) Poliosauridæ, Ophiacodontidæ, Sphen-
acodontidæ, Edaphosauridæ
 - Order Therapsida
 - Suborder Dinocephalia
 - Suborder Dromasauria
 - Suborder Anomodontia
 - Suborder Gorgonopsia
 - Suborder Therocephalia
 - Suborder Bauriamorpha
 - Suborder Cynodontia
 - Order Placodontia
 - Order Sauropterygia
 - Suborder Nothosauria
 - Suborder Plesiosauria
- Series C PARAPSIDA
 - Order Protorosauria
 - Order Squamata
 - Order Proganosauria
 - Order Ichthyosauria
- Series D RHYNCHOCEPHALIDA
 - Order Rhynchocephalia
 - Order Choristodera
 - ?Order Thalattosauria
- Series E DIAPSIDA (= ARCHOSAURIA in part)
 - Order Thecodontia
 - Suborder Pseudosuchia
 - Suborder Pelycosimia Erythrosuchidæ
 - Suborder Phytosauria
 - Order Crocodilia
 - Order Saurischia (= Dinosauria in part)
 - Suborder Theropoda
 - Suborder Sauropoda
 - Order Ornithischia (= Dinosauria in part)
 - Suborder Iguanodontia (= Ornithopoda)
 - Suborder Stegosauria
 - Suborder Ceratopsia

Order Pterosauria	
Class AVES	
Subclass SAURURÆ	
Order Archæornithes	<i>Archæopteryx</i>
Subclass ORNITHURÆ	
Order Megistanes	Emus, Cassowaries, Kiwis, Moas
Order Struthiones, etc.	
Class MAMMALIA ¹	
Subclass A. PROMAMMALIA	
Order Protodonta	
Subclass B. PROTOTHERIA	
Order Monotremata	
Subclass C. METATHERIA	
Order Triconodonta	
Order Multituberculata (Allotheria)	
Order Marsupialia	
Subclass D. EUTHERIA Huxley (PLACENTALIA)	
Order Trituberculata	
Order Insectivora (Lipotyphla)	
Suborder Centetoidei (Zalamb-	
dodonta)	<i>Zalambdodonts, including Nesophontes</i>
Suborder Soricoidi	
Suborder Erinaceoidi	
Suborder Pantolestoidi	
Order Tillodontia	<i>Esthonyx, Tillotherium.</i>
Order Carnivora ²	
Suborder Procreodi	Oxyclænidæ
Suborder Acreodi	Mesonychidæ
Suborder Pseudocreodi	Hyænodonts, Oxyænida, etc.
Suborder Eucreodi	Miacidæ
Suborder Aeluroidæ	Viverridæ, Hyænidæ, Felidæ
Suborder Arctoidea	Canidæ, Procyonidæ, Ursidæ,
	Mustelidæ
Suborder Pinnipedia	
Order Cetacea	
Suborder Archæoceti	
Suborder Mystacoceti	
Suborder Odontoceti	
Order Artiodactyla	
Order Amblypoda	
Suborder Taligrada	
Suborder Pantodonta	
Suborder Dinocerata	

¹The present classification of the mammalia has grown out of the classification adopted in 'The Orders of Mammals' (1910, Bull. Amer. Mus. Nat. Hist., XXVII) and is intended to reflect the chief advances of the last decade in this subject.

²See Matthew, W. D., 1909, Mem. Amer. Mus. Nat. Hist., IX, pp. 321-331; 1915, Bull. Amer. Mus. Nat. Hist., XXXIV, p. 5.

- Order Embrithopoda
- Order Pyrotheria
- Order Proboscidea
- Order Sirenia
- Order Condylarthra
- Order Tubulidentata
- Order Litopterna
- Order Notoungulata
 - Suborder Entelonychia
 - Suborder Astrapotheria
 - Suborder Toxodontia
 - Suborder Typotheria
- Order Hyracoidea
- Order Perissodactyla
- Order Edentata¹
 - Suborder Tæniodonta
 - Suborder Palæanodontia
 - Suborder Xenarthra
 - Suborder Pholidota
- Order Rodentia²
 - Suborder Sciuromorpha
 - Suborder Myomorpha
 - Suborder Dipodomorpha
 - Suborder Hystricomorpha
- Order Lagomorpha
- Order Dermoptera
- Order Chiroptera
- Order Menotyphla
- Order Primates³
 - Suborder Lemuroidea
 - Suborder Tarsioidea
 - Suborder Anthroipoidea

¹For a recent classification of the Edentates see Matthew, W. D., 1918, *Bull. Amer. Mus. Nat. Hist.*, XXXVIII, p. 656.

²For a recent classification of the Rodents see Miller, G. S. and Gidley, J. W., 1918, *Journ. Washington Acad. Sci.*, VIII, pp. 431-448.

³For a recent classification of the Primates see Gregory, W. K., 1915, *Bull. Geol. Soc. Amer.*; XXVI, pp. 426-444; 1916, *Bull. Amer. Mus. Nat. Hist.*, XXXV, pp. 266-267.

CLASSIFICATION, ACCORDING TO FUNCTION AND POSITION, OF THE SKULL
ELEMENTS FIGURED IN THIS WORK, WITH ABBREVIATIONS USED IN
THE ILLUSTRATIONS

A. SKULLS OF FISHES (Figs. 1-7)

1. Mouth and Jaw Bones

pmx.—premaxilla

mx.—maxilla

spx.—supramaxilla

v.—prevomers ("vomeres" of fish)

pa. sp.—parasphenoid (= vomer of mammals)

ect. pt.—ectopterygoid

en. pt.—entopterygoid (pterygoid)

mt. pt.—metapterygoid

pl.—palatine

qu.—quadrate

sym.—symplectic

hm.—hyomandibular

d.—dentary

ang.—angular

2. Circumorbital Series

pf.—prefrontal

l.—lacrymal, l¹, l², subdivisions of lacrymal

j.—jugal, j¹, j², subdivisions of jugal

po.—postorbital, po¹, po², subdivisions of postorbital

pof.—postfrontal

3. Median and Paired Elements on Roof of Endocranium

in.—internasal

"ad.n."—"adnasal"

if.—("eth") interfrontal ("ethmoid")

f.—frontal

pa.—parietal

4. Temporal Region

it.—intertemporal ("sphenotic")

st.—supratemporal ("pterotic")

sq.—squamosal ("cheek plate")

p. op.—preoperculum

qu. j.—quadratojugal

5. Nuchal, Opercular, and Gular Region

dso.—dermosupraoccipital ("supratemporal" of fish)

tb.—tabular ("epiotic")

op.—operculum

s. op.—suboperculum

i. op.—interoperculum

br. st.—branchiostegal

g.—gular

6. Elements of the Endocranium

pa. eth.—parethmoid (ossification of the lateral portion of the olfactory capsule)

sph. eth.—sphenethmoid

B. SKULLS OF TETRAPODA (Figs. 8-196)

1. Mouth and Jaw Bones

pmx.—premaxilla

mx.—maxilla

pl.—palatine

pt.—pterygoid

ecpt.—ectopterygoid

qu.—quadrate

pasp.—parasphenoid (= vomer)

v.—vomer (parasphenoid)

pv.—prevomer

2. Circumorbital Series

pf.—prefrontal

l.—lacrymal

j.—jugal

po.—postorbital

pof.—postfrontal

3. Median and Paired Elements on Roof of Endocranium

n.—nasals

if.—interfrontal

f.—frontal

pa.—parietal

4. Temporal Region

it.—intertemporal

st.—supratemporal

sq.—squamosal

quj.—quadratojugal

5. Nuchal and Occipital Region

dso.—dermosupraoccipital

tb.—tabular

6. Elements of the Endocranium

eth.—ethmoid

lsp.—laterosphenoid

osp.—orbitosphenoid

a.s.—alisphenoid

ANALYSIS AND CLASSIFICATION OF TYPICAL CONDITIONS OF THE
LACRYMAL AND SURROUNDING PARTS IN REPTILES, BIRDS, AND
MAMMALS

I. Prefrontal present.

1. Lacrymal present.

A¹. Lacrymal extending from orbit to anterior naris. *Cotylosauria* (except *Procolophon*), *Naosaurus*, *Triassochelys*.

A². Lacrymal not extending from orbit to anterior naris.

(1) Lacrymal in contact with nasal.

a¹. Lacrymal extending rostrad beyond prefrontal.

b¹. Maxilla not in contact with prefrontal.

c¹. No antorbital fenestra. *Sphenacodon*, many Therapsida, most Crocodilia.

c². Antorbital fenestra present.

d¹. Premaxilla not in contact with lacrymal. *Euparkeria*, *Mystriosuchus*, *Triceratops*, *Tyrannosaurus*.

d². Premaxilla in contact with lacrymal. *Camplosaurus*, *Gryposaurus*.

b². Maxilla in contact with prefrontal. Some therapsids, *Scylacops*.

a². Lacrymal not extending rostrad beyond prefrontal. *Procolophon*.

(2) Lacrymal not in contact with nasal (separated from it by prefrontal).

a¹. Maxilla barely in contact with prefrontal. *Mycterosaurus*.

a². Maxilla in wide contact with prefrontal.

b¹. Lacrymal not reduced. *Alligator*.

b². Lacrymal reduced. *Aræoscelis*, *Lacerta*, *Cyclura*.

2. Lacrymal absent, its place usurped by prefrontal.

A¹. Maxilla in contact with prefrontal.

(1). Premaxilla in contact with nasal. *Sphenodon*.

(2). Premaxilla not in contact with nasal. *Chelone*.

A². Maxilla not in contact with prefrontal.

(1). Prefrontal in contact with palatine. *Python*, *Boa*.

(2). Prefrontal not in contact with palatine. *Casuarius*.

II. Prefrontal and postorbital bones absent.

1. Lacrymal absent. Monotremes, *Polymastodon*, *Potamogale*, *Manis*, Phocidæ.

2. Lacrymal present.

A¹. A primitive (?) naso-lacrymal contact, lacrymal forming distinct rim on anterosuperior margin of orbit. Lacrymal foramen internal. Lacrymal in contact with jugal. Pars facialis small. Several marsupials, e.g., *Amphiproviverra*, *Borhyaena tuberculata*, *Wynyardia*.

A². A maxillo-frontal contact above lacrymal.

(1) Orbit not closed posteriorly by jugal and frontal.

a¹. Lacrymal in contact with jugal.

b¹. Lacrymal large, extended vertically, often bearing on

- . the dorso-anterior margin of orbit a prominent rim, which is inclined upward and backward. Pars facialis often extended.
- c¹. Jugal not extending in front of orbit.
 - d¹. Lacrymal foramen internal, pars facialis small. *Palæothentes*.
 - d². Lacrymal foramen marginal or external. Pars facialis large.
 - e¹. Tubercle and rim prominent. *Dasyuridæ*, *Peramelidæ*, *Macropus*, *Phalangista*.
 - e². Tubercle and rim not prominent. *Didelphis*.
- c². Jugal extending in front of orbit, pars facialis reduced, tubercle prominent. *Phascolarctos*, *Phascolomys*.
- b². Lacrymal large, with large pars facialis; lacrymal rim on anterior border of orbit, if developed, not markedly inclined upward and backward.
 - c¹. Lacrymal foramen internal, tubercle prominent. Most creodonts, *Perchærus*, *Dichobune* Archæoceti.
 - c². Lacrymal foramen external, pars facialis much extended anteroposteriorly. *Orycteropus*, many Suina, Myrmecophagidæ.
 - c³. As above; jugal meeting frontal behind lacrymal. *Dasypodidæ*.
- b³. Pars facialis developed dorsally, tubercle prominent, foramen internal. *Phenacodus*, *Meniscotherium* *Hegetotherium*, *Pachyrhinos*.
- b⁴. Lacrymal more or less reduced on anterior rim of orbit, pars facialis slight or wanting. Jugal often extending in front of lacrymal. Lacrymal foramen internal. Most Fissipedia.
- b⁵. Pars facialis not large, pars orbitalis in contact with a medial process of the jugal. Sloths, glyptodonts.
- b⁶. Pars facialis small or wanting, lacrymal displaced dorsad by upgrowth of jugal and of zygomatic plate of maxilla. Many rodents.
- b⁷. Lacrymal flattened beneath widely projecting supra-orbital apophysis of frontals. *Odontoceti*.
- b⁸. Lacrymal forming a long sliver of bone between the orbital apophysis of the frontal and the maxilla. *Mystacoceti*.
- b⁹. Pars orbitalis extended anteroposteriorly by forward shifting of orbits. Lacrymal forming anterior rim of orbit. *Sirenia*.
- a². Lacrymal not in contact with jugal, which, if present, is separated from lacrymal by maxilla.
 - b¹. Lacrymal vestigial, jugal large, extending to anterior

rim of orbit. *Ursus* sp. div.

- b². Lacrymal a thin, more or less reduced lamina on the wall of the orbit, sometimes bearing a small tubercle. *Lutra*, *Lutax*, *Spilogale*, *Eumetopias*.
- b³. Lacrymal with a distinct orbital rim and expanded pars orbitalis, foramen marginal. Jugal more or less reduced. *Leptictidæ*, *Erinaceidæ*.
- b⁴. Lacrymal on medial wall of orbit, extended obliquely upward and backward, above enlarged infraorbital tunnel. Lacrymal foramen external; jugal absent. Most zalambdodonts.
- b⁵. Lacrymal expanded in front of orbit, above large tunnel for masseter medialis. *Hydrochaerus*.
- b⁶. Lacrymal very small, on anterosuperior rim of orbit. *Protypotherium*, *Interatherium*.
- b⁷. Lacrymal on anterior margin of orbit, bearing stout tubercle and separated from the palatine by the maxilla. *Mastodon*, *Elephas*.

(2) Jugal meeting frontal behind orbit.

- a¹. Pars facialis expanded dorsally. A double tubercle. Lacrymal in contact with jugal. *Diadiaphorus*.
- a². Pars facialis expanded anteroposteriorly. Tubercle often prominent, lacrymal foramen mostly internal. Lacrymal in contact with jugal. *Megalohyrax*, many *Artiodactyla*, *Tupaia*, *Rhynchocyon*.
- a³. Pars facialis reduced, tubercle prominent, foramen internal. Lacrymal separated from jugal by maxilla. *Dendrohyrax*.
- a⁴. Pars facialis variable, occasionally extended secondarily. (*Lemur*) or small or absent (*Adapis*, *Archaeolemur*). Lacrymal fossa and duct between lacrymal and maxilla. Lacrymal usually in contact with jugal. *Adapis*, *Notharctus*, *Lemur*, *Propithecus*.
- a⁵. Lacrymal forming prominent anterior rim of orbit (crista orbitalis), pars facialis small, a fronto-maxillary contact, lacrymal foramen prominent in front of lacrymal.
 - b¹. Lacrymal in contact with jugal. *Necrolemur*.
 - b². Lacrymal separated from jugal by maxilla. *Perodicticus*, *Galago*, *Tarsius*.
- a⁶. Lacrymal on inner wall of orbit, extended vertically. Lacrymal fossa and duct chiefly anterior to lacrymal. Lacrymal separated from nasal by narrow fronto-maxillary contact. Lacrymal separated from jugal by maxilla. Anthropoid apes, *Homo*.

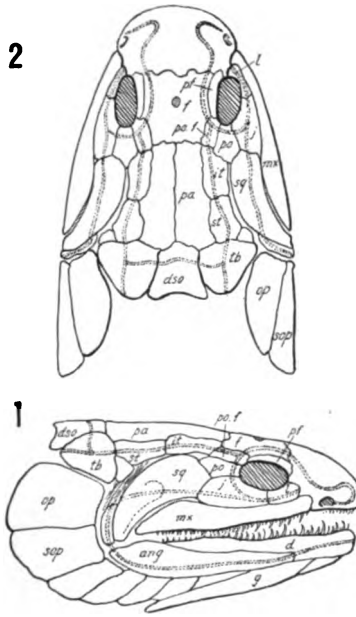
A³. A secondary naso-frontal contact.

- (1) Pars facialis of lacrymal extended. Lacrymal in contact with jugal.
 - a¹. Orbit not closed posteriorly. Many perissodactyls.
 - a². Orbit closed posteriorly by postorbital processes of frontal and jugal. *Equidæ*.

- (2) Pars facialis reduced, lacrymal separated from jugal by maxilla. Orbit closed posteriorly. Lacrymal fossa and duct between lacrymal and maxilla. Many *Platyrrhinæ*.
- A⁴. Lacrymal in contact with premaxilla. No maxillo-frontal contact. Otherwise much as in *Lemur*. *Chiromys*.

ORIGIN AND EVOLUTION OF THE LACRYMAL IN THE
LOWER VERTEBRATES
Fishes

In the rhipidistian, or osteolepidote fish (Figs. 1 and 2) of the Paleozoic era, there is a ring of dermal bones around the orbit which, as a whole, corresponds to the circumorbital series of contemporary and later Actinopterygii (Figs. 3-6) and to a similar series in the Dipnoi. Of these elements, the one at the antero-inferior corner of the orbit very



Osteolepis macrolepidotus

Figs. 1, 2. Head of a very primitive rhipidistian fish *Osteolepis macrolepidotus* from the Old Red Sandstone, Scotland. Enlarged. After Goodrich.

1. Side view. 2. Dorsal view.
Main lateral line canals indicated by dotted lines.

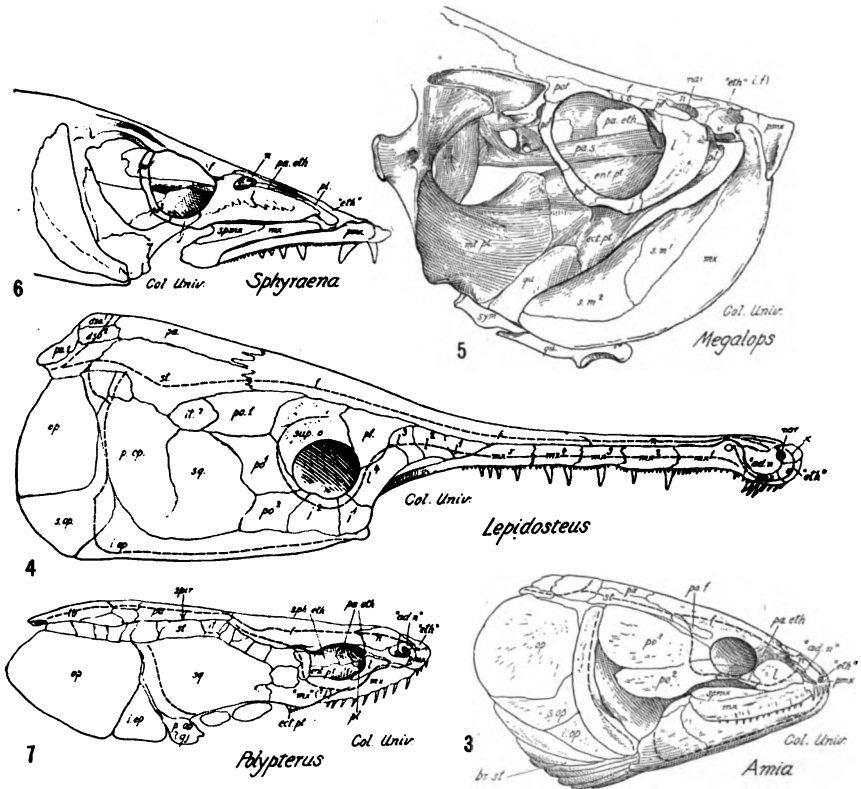
probably represents the mammalian lacrymal, since it has been traced forward from the Rhipidistii¹ through the earliest amphibians and reptiles into the cynodont reptiles, where its homology is clearly established.² The remaining bones of the series in the Rhipidistii, beginning at the anterosuperior border of the orbit, represent the prefrontal,³

¹1915, Ann. N. Y. Acad. Sci., pp. 330-337.

²1913, Journ. Morphol., pp. 3, 4; 1915, Ann. N. Y. Acad. Sci., pp. 330-337.

³Watson and Day, 1916, and Goodrich, 1919.

postfrontal, postorbital, and jugal, respectively, of tetrapod vertebrates. Accordingly, the lacrymal, at its very first appearance in the distant Paleozoic ages, is associated with a set of bones with which, in spite of all the readjustments involved in the evolution of certain fishes into tetrapods, it persistently retains connection.



Figs. 3 to 7. Skulls of Ganoids, Teleosts and *Polypterus*.

3. *Amia calva*. Class Actinopterygii, Order Holostei, family Amiidae. Young specimen. Lateral line canals after Allis.
4. *Lepidosteus tristachys*. Class Actinopterygii, order Holostei, family Lepidosteidae. Lateral line canals adapted from Goodrich, after Allis and Collinge.
5. *Tarpon atlanticus*. Class Actinopterygii, order Isopondyli, family Elopidae.
6. *Sphyræna barracuda*. Class Actinopterygii, order Acanthopterygii, suborder Percosoces, family Sphyrænidæ.
7. *Polypterus bichir*. Class Crossopterygii, order Cladistia, family Polypteridae.

Another bone with which the lacrymal of fishes often gains contact is the palatine. At this stage the lacrymal is separated from the frontal by the prefrontal and the parethmoid.

In *Polypterus* (Fig. 7) the lacrymal is a small wedge-shaped element in the antero-inferior corner of the orbit, which extends toward the nose and begins to resemble the lacrymal of later types. In the dried skull of this fish there is a tunnel beneath the lacrymal which runs forward toward the nostril. At first sight it suggests the naso-lacrymal duct of tetrapods, but Pollard's dissections (1892) show that it transmits the superior maxillary branch of the fifth nerve, which in later types passes through the maxillary.

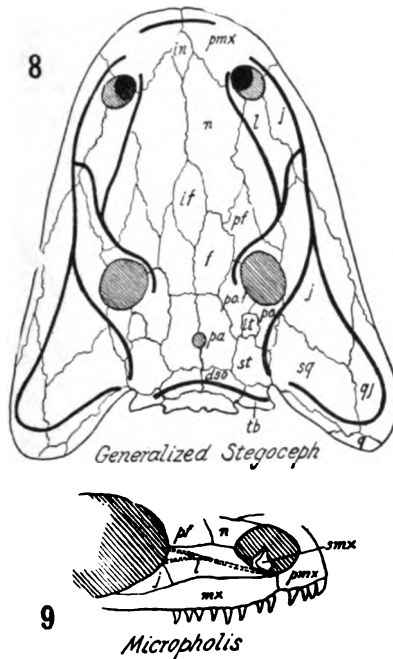


Fig. 8. Generalized stegoceph skull, showing location of sensory grooves. After Moodie.

Fig. 9. Fore part of skull of *Micropholis stowi*, showing course of naso-lacrymal duct. After Watson.

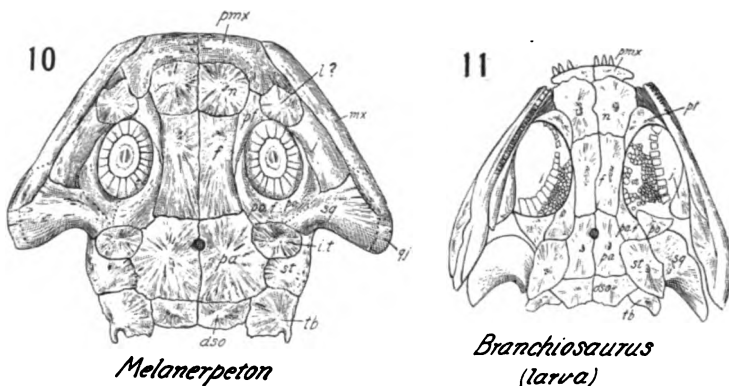
The lacrymal of primitive fishes bears on its outer surface a branch of the "lateral line system," which is supposed by Baur (1896), Allis (1899), Moodie (1908), and others to have given rise to the "sensory grooves" on the surface of the skull of stegocephs (Fig. 8). It has been suggested by Watson (1913) that the naso-lacrymal duct of later tetrapods may be a special derivative of these sensory grooves.

Amphibia

In his description of the skull of *Micropholis stowi* (Fig. 9), a small stegoceph from the Trias of South Africa, Watson refers to the naso-lacrymal duct of this animal in the following passage:

Four of the skulls show very clearly the course of the ductus naso-lacrymalis, which is a narrow canal running in the substance of the lacrymal bone from the orbit, which it leaves by two openings, to the nostril, where it opens behind and below the septomaxilla. This is, I believe, the first recognition of a ductus naso-lacrymalis in the Stegocephalia, and the occurrence is very interesting from several points of view:—

(a) The very superficial position of the duct. In development in recent types this begins merely as an epidermal thickening which grows down into the head and subsequently acquires a lumen; in *Micropholis* we have an early condition where the duct is still in the skin and has not yet sunk at all deeply.

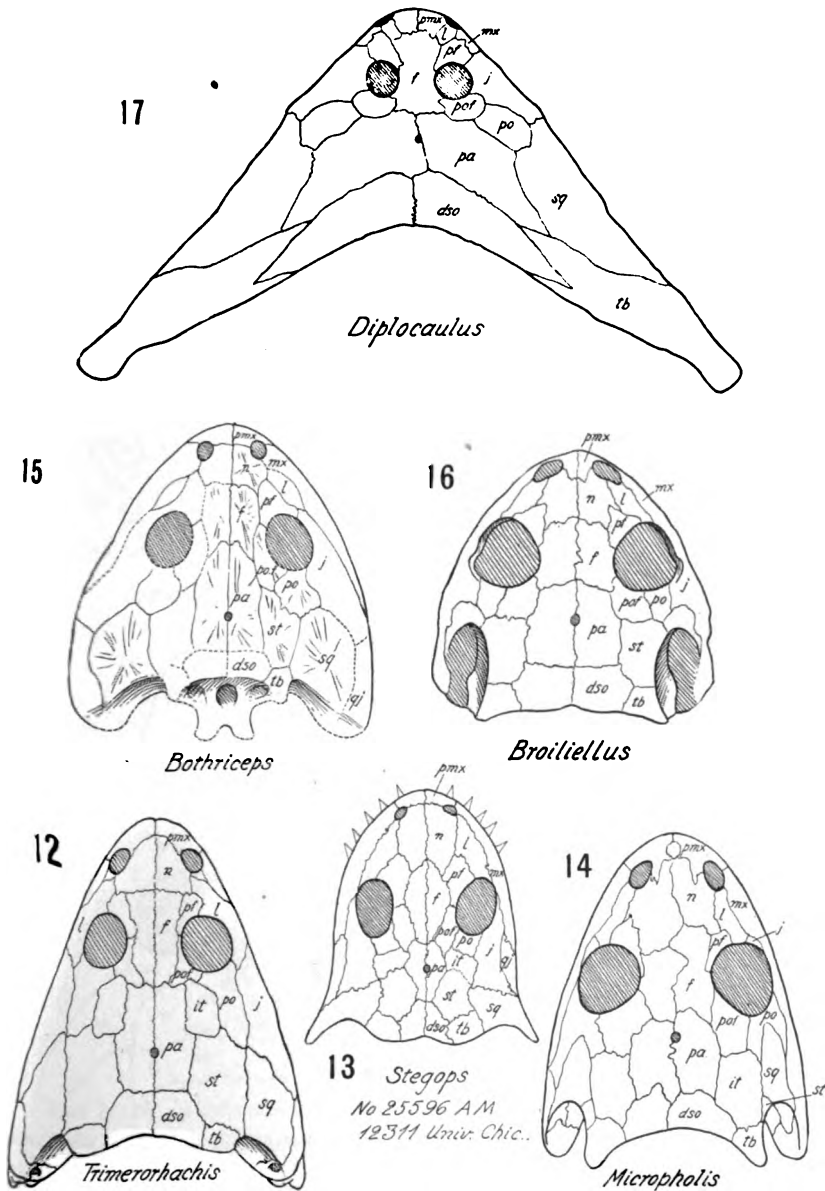


Figs. 10 to 11. Skulls of Branchiosaurs. Class Amphibia, subclass Stegocephalia, order Phyllospondyli.

10. *Melanerpeton salax*. Family Apateonidae. Permian, Bohemia. After Fritsch. Presence of lacrymal doubtful.
11. *Branchiosaurus amblystoma*. Family Branchiosauridae. Permian, Saxony. After Credner. Lacrymal absent.

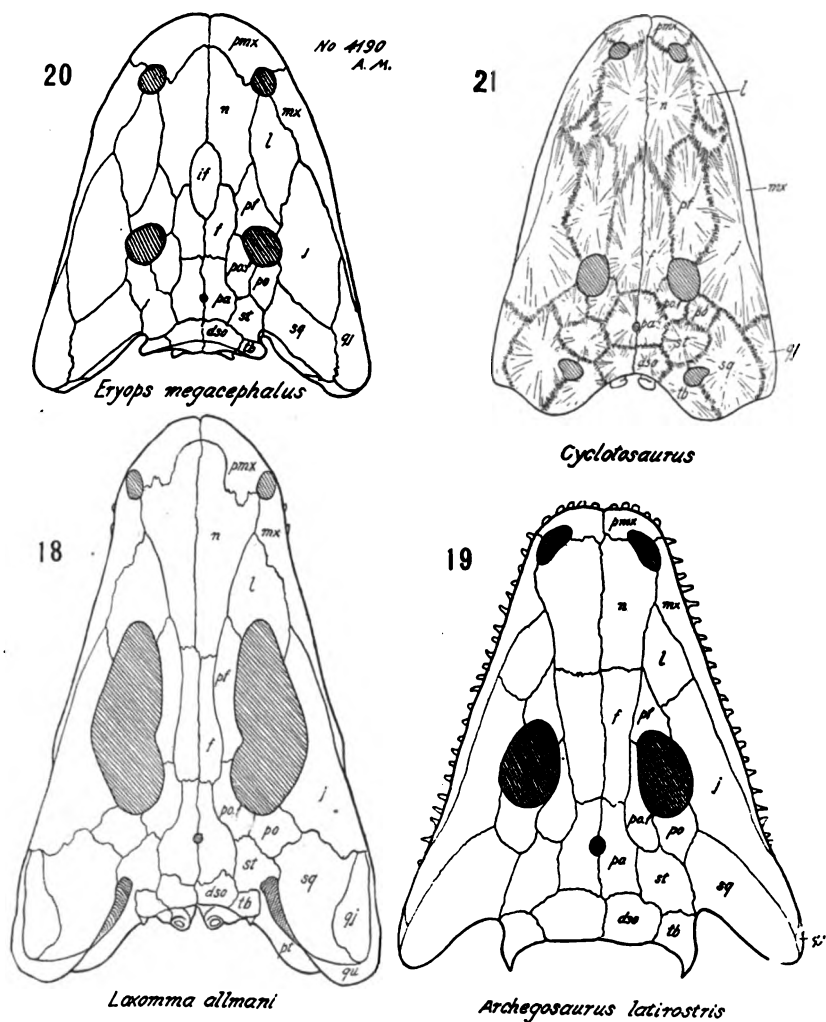
(b) The very great forward extension of the duct and its very unusual exit, practically on the outer surface and just behind the septomaxilla, are of interest. The duct only occurs in Tetrapoda, never in fish, and its origin is obscure; it may be suggested that it is possible that it has been derived from one of the lateral line canals so commonly found in Stegocephalia, of which there is no trace in *Micropholis*. (*Op. cit.*, pp, 342-343.)

In modern urodeles the naso-lacrymal duct, which is continuous with the lacrymal glands, is developed as a solid epithelial cord which follows the cleft leading from the orbit to the nares and lies between the maxillary and lateral nasal processes of the embryonic head. (Keith,



Figs. 12 to 17. Skulls of various Stegocephs. Class Amphibia, subclass Stegocephalia.

12. *Trimerorhachis insignis*. Order Temnospondyli, suborder Rhachitomi, family Trimerorhachidae. Permo-Carboniferous, Clear Fork, Texas. After Williston.
13. *Stegops divaricata*. Order uncertain, family Stegopidae. Coal Measures, Ohio. After Moodie.
14. *Micropholis stowi*. Order Temnospondyli, suborder Rhachitomi, family Micropholidae. Middle Triassic, Procolophon zone, South Africa. After Watson.
15. *Bothriceps australis*. Order Temnospondyli, suborder Rhachitomi, family Brachyopidae. Middle Triassic, Procolophon zone, South Africa. After Broom.
16. *Broiliellus tezensis*. Order Temnospondyli, suborder Rhachitomi, family Dissorhophidae. Permo-Carboniferous, Texas. After Williston.
17. *Diplocaulus megacephalus*. Order Lepospondyli, family Diplocaulidae. Permo-Carboniferous, Texas. After Douthitt.

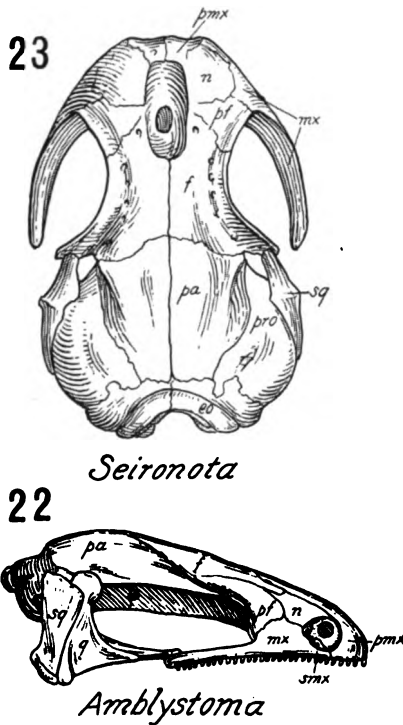


Figs. 18 to 21. Skulls of Stegocephala. Class Amphibia, subclass Stegocephalia, order Temnospondyli.

18. "*Loxomma*" *altmani*. Suborder Embolomeri, family Loxommatidae. Upper Carboniferous, Northumberland, England. After Embleton and Atthey.
19. *Archegosaurus latirostris*. Suborder Rhachitomi, family Archegosauridae. Lower Permian, Rhine Province, Germany. After H. von Meyer.
20. *Eryops megacephalus*. Suborder Rhachitomi, family Eryopidae. Permo-Carboniferous, Texas.
21. *Cyclotosaurus robustus*. Suborder Stereospondyli, family Mastodonsauridae. Upper Triassic, Swabia, Germany.

Kingsley.) In urodeles that retain a lacrymal bone (see below, p. 224) it is pierced by the naso-lacrymal duct.

In all really primitive fishes the eyes are located near the front end of the head, not far behind the nostrils, and the same is true of all the more primitive Palæozoic amphibians and reptiles. Hence, it is not surprising that the lacrymal bone at the antero-inferior corner of the orbit often has a wide contact with the nasal bone and extends far toward the nares.



Figs. 22, 23. Skulls of modern Urodeles showing loss of the lacrymal and retention of the prefrontal. Class Amphibia, subclass Euamphibia.

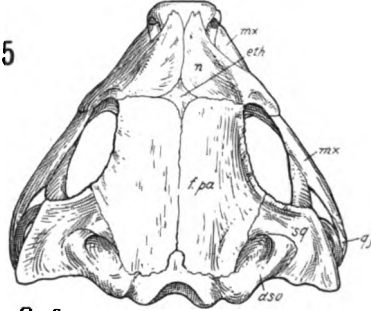
22. *Amblystoma opacum*. Order Urodela, suborder Myctodera, family Amblystomidae. After W. K. Parker.

23. *Seironota* (= *Salamandrina*) *perspicillata*. Order Urodela, suborder Myctodera, family Salamandridae. After W. K. Parker.

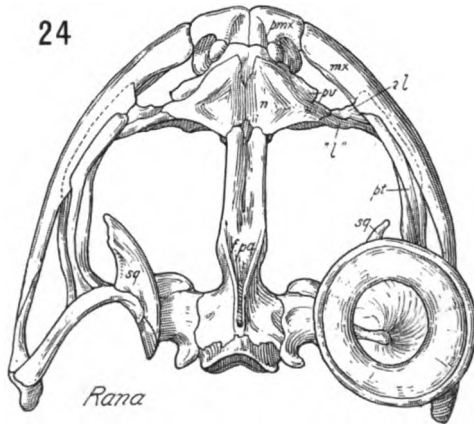
As a rule, the snout of both Rhipidistii and early Amphibia is wide and depressed, with wide premaxillæ and nasals and laterally placed nares. The maxilla is vertically shallow, never extended dorsad on the face.

In many of the early Amphibia the lacrymal is excluded from the orbital border by the downward growth of the prefrontal which gains contact with the jugal (Figs. 15, 17, 19, 21); but this specialization is avoided by the very ancient stegoceph *Loxomma* (Fig. 18) and by all the primitive reptiles.

25

*Bufo*

24

*Rana*

Figs. 24, 25. Skulls of modern Anura. Class Amphibia, subclass Euamphibia, order Anura. After W. K. Parker.

24. *Rana pipiens*. Family Ranidae.

Two small bones between the nasals and the maxilla were called by W. K. Parker "pre-orbital" and "anterior suborbital" or lacrymal respectively. By comparison with *Bothriiceps* (Fig. 15) and *Broiliellus* (Fig. 16), the anterior bone (?) is seen to have the general position of the lacrymal, while the posterior bone ("1") bone, suggests the prefrontal.

25. *Bufo ornatus*. Family Bufonidae. No trace of the prefrontal or of the lacrymal is present. The skull roof is secondarily widened.

At least in *Trematosaurus sobeyi* Haughton the lacrymal was pierced by a large duct and was in contact below with the palatine (cf. Haughton, 1915, Fig. 6, page 51). These conditions thus afford evidence in favor of the Cuvierian view that the bone usually called

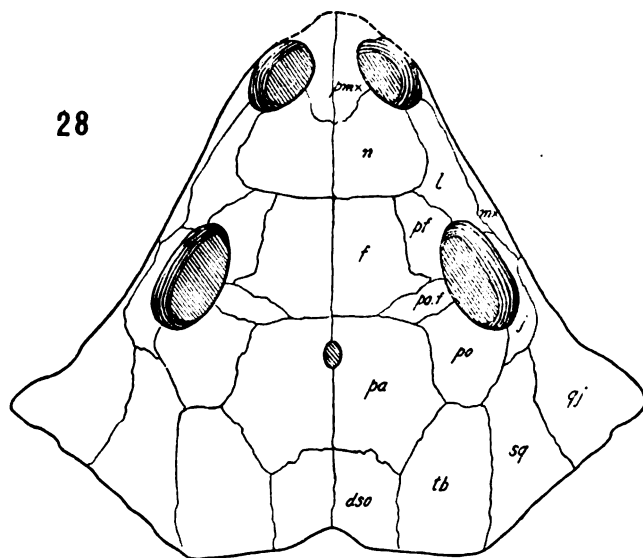
"lacrymal" in the lower vertebrates is rightly identified with that element in the therapsids and mammals. In this stegoceph the lacrymal was extended from the orbit beyond the prefrontal, but was excluded from the nostril and the septomaxilla by the naso-maxillary contact.

Most of the recent Amphibia (Figs. 22-25) have sacrificed the lacrymal, together with many other dermal elements, but a small element in *Ranodon* and *Ellipsoglossa*, which was named *Præfrontale* II (Pf' of Taf. xxiii, Figs. 64, 69) by Wiedersheim (1877, p. 418), is regarded by the Sarasins as a true lacrymal (1887-1890, p. 157). Wiedersheim (*loc. cit.*) represents the lacrymal at the anterior inferior part of the orbit, articulating with the prefrontal, nasal, and maxilla. Cope (1889, Pl. xxii, fig. 1) shows that the lacrymal is retained by *Gyrinophilus*, which is in many respects the most primitive Plethodontid. In this genus the lacrymal is excluded from contact with the nasal by the broad contact of maxilla and prefrontal. The "nasale laterale" (Wiedersheim) of cæcilians, which has the position of a lacrymal, has been shown by the Sarasins (*op. cit.*, pp. 155-157) to be an exposed flange of the olfactory capsule and is named by them "turbinale."

Primitive Reptiles

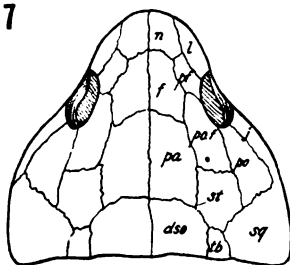
In the primitive reptiles of Permo-Carboniferous times (Figs. 26, 29, 30) the skull is deepened by the downward growth of the suspensoria of the jaws, the snout is more or less pointed, the opposite nares being nearer together than was the case in the stegocephs. The lacrymal retains its wide contact with the nasals and is extended longitudinally from the orbit to the nares. The whole circumorbital ring of bones (Figs. 29-35) is intact and little modified and the maxilla is primitively not extended dorsad on the side of face. In the Triassic *Procolophon* (Fig. 33), the last survivor of the cotylosaurs, the enlargement of the orbit and the dorsal growth of the maxilla have contributed to the reduction of the lacrymal, which now parallels that of certain lizards and is becoming smaller than the prefrontal (cf. Watson, 1914).

In the Chelonia (Fig. 36), which doubtless represent a highly specialized offshoot of the Cotylosauria, the true lacrymal has disappeared along with several other elements of the dermal skull, its place being usurped by the prefrontal. Jaekel (1916, Taf. iv, v, and pp. 143-145) figures in *Stegochelys* (*Triassochelys*) *dux* a suture separating the maxilla below from the "postnasale" (lacrymal) above, which is represented as a separate element extending from the anterior nares nearly to the orbit.

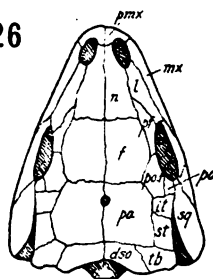


"Pariasaurus"

27

*Pantylus*

26

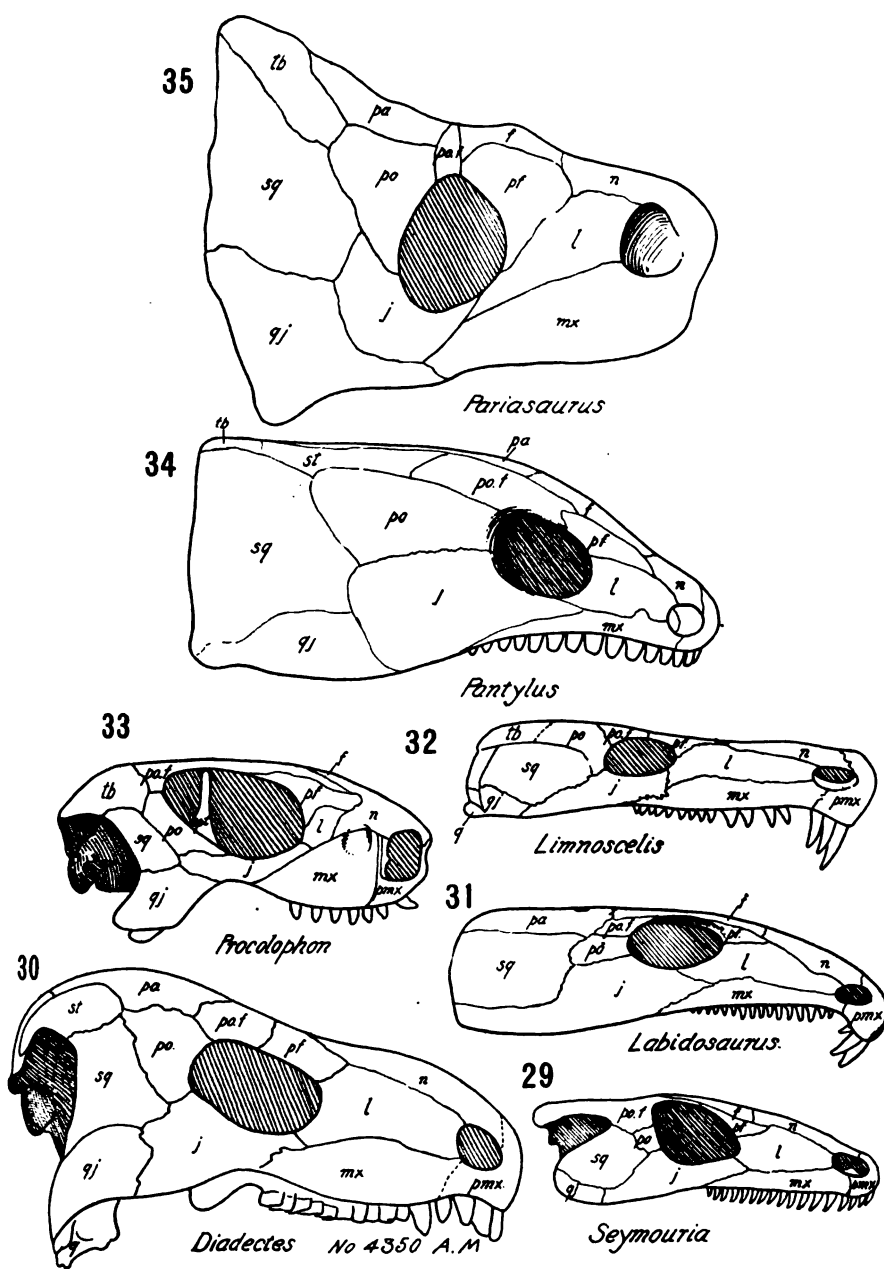
*Seymouria*

Figs. 26 to 28. Skulls of Cotylosaurs. Class Reptilia, series Anapsida, order Cotylosauria.

26. *Seymouria baylorensis*. Suborder Seymouriamorpha, family Seymouriidae. Permo-Carboniferous, Texas. After Williston.

27. *Pantylus cordatus*. Suborder Captorhinomorpha, family Pantylidae. Permo-Carboniferous, Texas. After Williston.

28. "Pariasaurus." Suborder Pariasauria, family Pariasauridae. Middle Permian, Pariasaurus zone, Gough district, South Africa. After Watson.



Figs. 29 to 35. Skulls of Cotylosaurs. Class Reptilia, series Anapsida, orde Cotylosauria.

29. *Seymouria baylorensis*. Suborder Seymouriamorpha, family Seymouriidae. Permo-Carboniferous, Clear Fork, Texas. After Williston.
30. *Diadectes* (*Empedias*) *molaris*. Suborder Diadectomorpha, family Diadectidae. Permo-Carboniferous, Texas. After Broom.
31. *Labidosaurus* sp. Suborder Captorhinomorpha, family Captorhinidae, Uppermost Clear Fork, Texas. After Williston.
32. *Limnoscelis paludis*. Suborder Captorhinomorpha, family Limnoscelidae. Permo-Carboniferous, New Mexico. After Williston.
33. *Procolophon trigoniceps*. Suborder Diadectomorpha, family Procolophonidae, Middle. Triassic, Procolophon zone, Upper Beaufort beds, Dist. Queenstown, Cape Colony, South Africa. After Watson.
34. *Pantylus cordatus*. Suborder Captorhinomorpha, family Pantylidae. Permo-Carboniferous, Lower Clear Fork, Texas. After Williston.
35. "*Pariasaurus*," sp. Suborder Diadectomorpha, family Pariasauridae. Middle Permian, Pariasaurus zone, Gough district, Hottentots River, Cape Colony, South Africa.

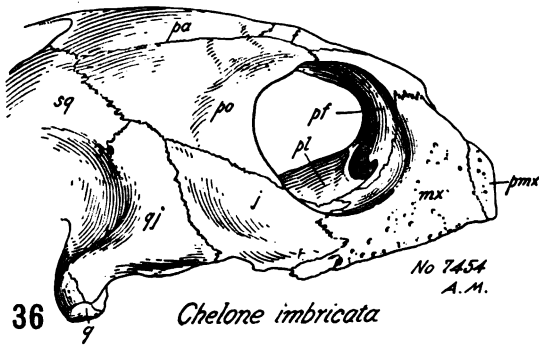
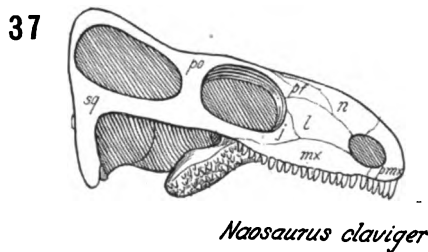
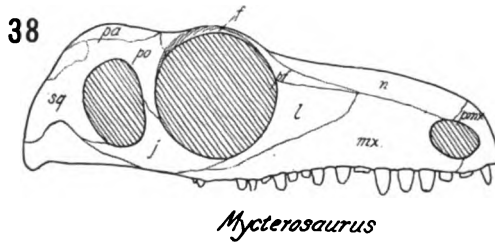
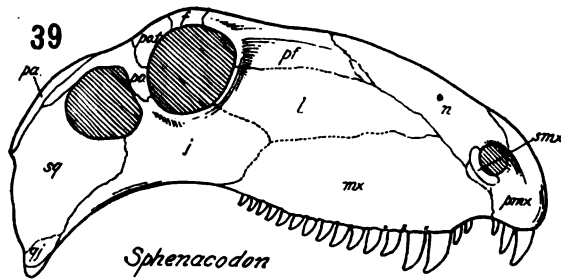


Fig. 36. *Chelone imbricata*. Class Reptilia, series Anapsida, order Testudinata, suborder Cryptodira, family Chelonidæ.



Figs. 37 to 39. Skulls of Pelycosaurs. Class Reptilia, series Synapsida, order Pelycosauria.

- 37. *Naosaurus claviger*. Family Edaphosauridæ. Permo-Carboniferous, Wichita beds, Texas. After Williston.
- 38. *Mycterosaurus longiceps*. Family Poliosauridæ (?). Permo-Carboniferous. Lower Clear Fork, Texas. After Williston.
- 39. *Sphenacodon*. Family Sphenacodontidæ. Permo-Carboniferous, New Mexico. After Williston.

Among the Pelycosaurs (Figs. 37-39) and their allies, as described by Williston, the lacrymal reaches the nares in *Varanops* and *Naosaurus*; but in *Mycterosaurus*, *Dimetrodon*, and other genera, through the upgrowth of the maxillary and the lengthening of the jaws in front of the orbit, it loses its connection with the nares and retains only a moderate extension on the face in front of the orbit.

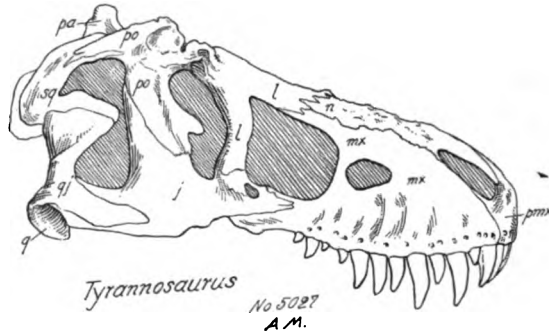
Diapsid Reptiles

The next higher grade above the pelycosaurs and allied forms is represented by the group of thecodont reptiles with two temporal fenestræ, including the aëtosauers, belodonts, crocodilians, dinosaurs, and pterosaurs, in all of which the prefrontals and the lacrymals are both present, and the lacrymal is always excluded from the nares by the upgrowth of the maxilla. A relatively primitive condition of the lacrymal in this series is illustrated in the type skull (Fig. 43) of *Euparkeria capensis* Broom (1913). "Here," writes Broom, "the lachrymal is an unusually large bone. It forms most of the anterior orbital margin. Above, it has a long articulation with the prefrontal; and below a short one with the jugal. Anteriorly it has a large development which forms the upper margin of the antorbital vacuity, meeting the ascending process of the maxilla. Of the anterior process much is below the level of the general surface of the face, suggestive of the antorbital vacuity having lodged a large gland. The prefrontal is a small narrow bone which forms about half of the upper orbital margin. It is bounded above by the frontal and nasal and below by the lachrymal."

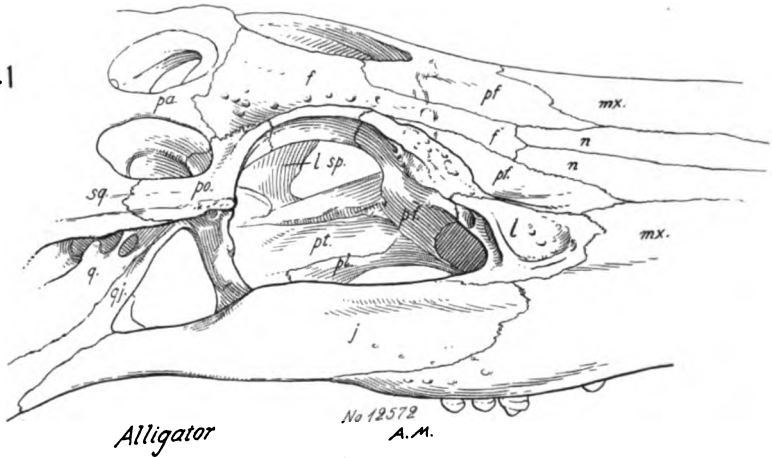
The enlargement and fenestration of the lacrymal and the small size of the prefrontal is greatly emphasized in the saurischian dinosaurs, in which the prefrontal is greatly reduced or wanting, and the lacrymal enormously enlarged. In *Tyrannosaurus* (Fig. 42), for example, the lacrymal forms a huge V-shaped brace with its apex directed upward and backward, the anterior limb articulating with the nasals and the ascending process of the maxilla, the posterior limb resting on the jugal. It has been suggested¹ that the antorbital fenestra, which is bounded above and behind by the lacrymal, did not serve for the lodgment of a large gland, as supposed by Broom, but that its inner borders gave insertion to a huge pterygoid muscle, homologous with the pterygoideus anterior of Crocodilia, which extends forward beneath the lacrymal. This suggestion seems to be strengthened by the form and relations of the

¹1915, *Science*, XLI, pp. 763-765; 1919, *Ann. N. Y. Acad. Sci.*, pp. 154, 155.

42



41



40

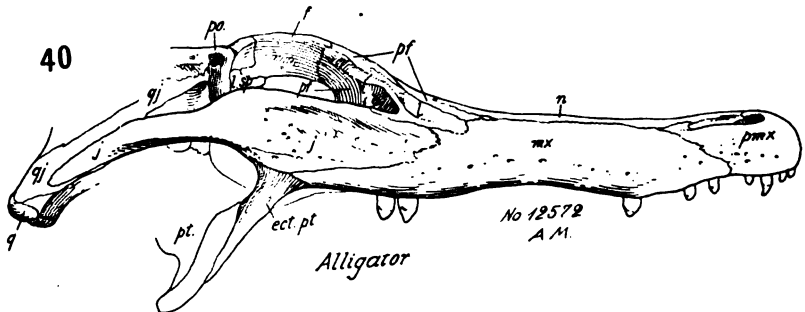


Fig. 40. Skull of *Alligator mississippiensis*. Class Reptilia, series Diapsida, order Crocodilia, suborder Eusuchia, family Alligatoridae.

Fig. 41. As in Fig. 40, oblique side-top view.

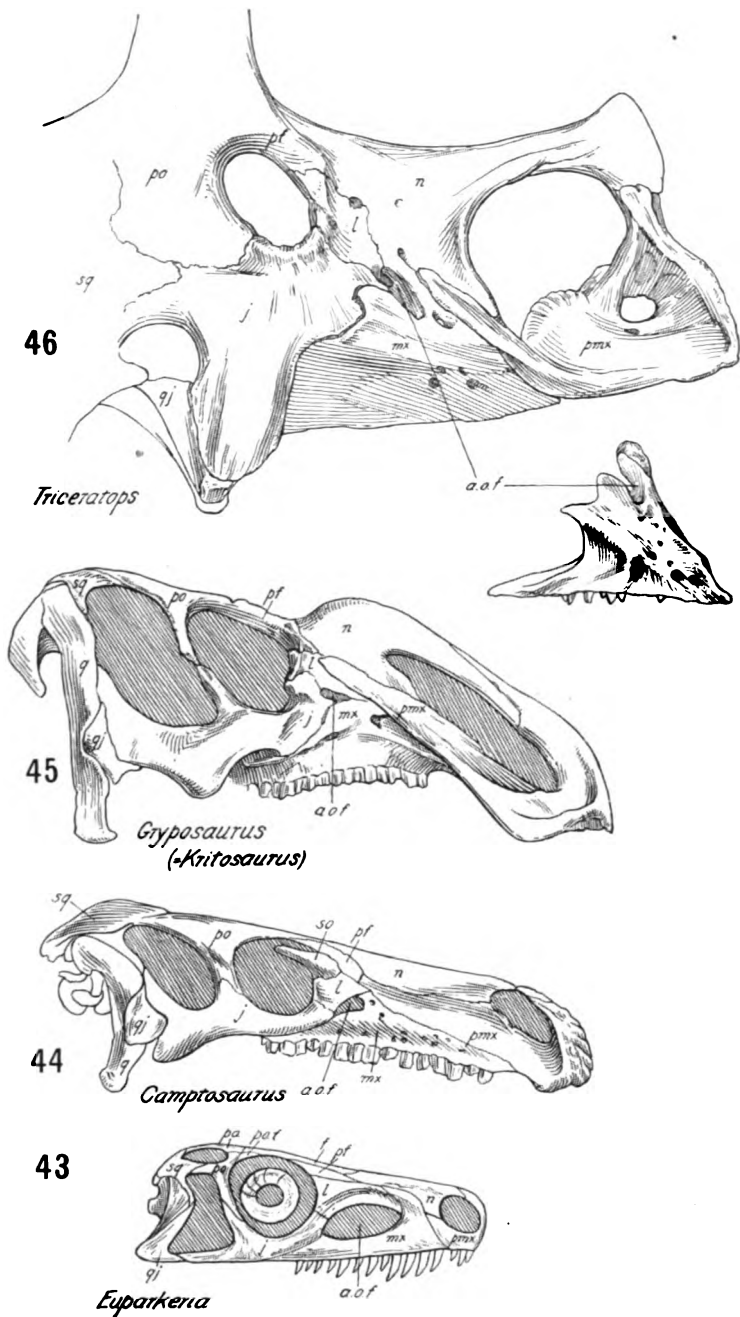
Fig. 42. *Tyrannosaurus rex*. Class Reptilia, series Diapsida, order Saurischia, suborder Theropoda, family Deinodontidae. Late Cretaceous, Lance Formation, Hell Creek beds, Montana. After Osborn.

antorbital fenestra of *Mystriosuchus*, as figured by McGregor (1906, Pl. VII). Here the general resemblance of the antorbital fenestra to the lateral temporal fenestra, which is known to be a muscle fossa, is very evident. In any case the lacrymal in all the thecodont reptiles plays an important part as a brace between the upper jaw and the frontal region of the skull.

The typical Crocodilia have a well-developed lacrymal bone, which is pierced by the naso-lacrymal duct and usually retains the normal reptilian connections with the nasal, prefrontal, maxilla, and jugal. Owing to the presence of a large tunnel (Fig. 41) in front of the orbits for the pterygoideus anterior muscle, the lacrymal is restricted to the upper part of the face and is widely separated from the palatine bone below. In form, proportions, and other characters the lacrymal differs widely in the different genera and families of this order. Among the thalattosuchians (cf. Fraas, 1902), it is greatly reduced in size and the prefrontal is correspondingly enlarged, while in *Teleosaurus*, *Osteolæmus*, *Tomistoma*, and most other Crocodilia it is much larger than the prefrontal. In *Diplocynodon* it is unusually large, in correlation with the widening of the snout. In *Alligator* (Figs. 40, 41) it loses its primitive contact with the nasals. In *Alligatorium meyeri* Jourdan, as figured by Lortet (1892, Pl. x), the lacrymal is essentially similar to that of *Alligator*, save that it retains a slight contact with the nasal.

The whole configuration of the facial elements of the relatively primitive ornithischian dinosaur *Camptosaurus* (Fig. 44), as figured by Gilmore (1909, p. 205), may readily be derived from the pattern in *Euparkeria* (Fig. 43) by a great increase in size of the premaxilla, which in turn was correlated with the development of a beak. This has crowded back the ascending process of the maxilla and greatly reduced the antorbital vacuity. In this way the premaxilla has gained contact with both the lacrymal and the prefrontal and has excluded the nasals from contact with the lacrymal. The reduced lacrymal, however, still borders the vestigial antorbital fenestra posteriorly and retains its primitive contact with the prefrontal above and the jugal below. Above it is a new derm bone, the presupraorbital, which attains a large size in *Stegosaurus*.

The pattern of the facial elements in *Iguanodon* (as figured by Dollo, 1883, Pl. ix) differs from that of *Camptosaurus* in the deepening of the maxilla, which is in wide contact with the nasals, and separates the premaxilla from the prefrontals. The antorbital fossa is almost vestigial and the lacrymal is now very small but retains its normal contacts with



Figs. 43 to 46. Skulls of a pseudosuchian (*Euparkeria*) and of typical ornithischian dinosaurs, showing the retraction of the lacrymal, the reduction of the antorbital fenestra, and the backward extension of the premaxilla in the Ornithischia.

43. *Euparkeria capensis*. Class Reptilia, series Diapsida, order Thecodontia, suborder Pseudosuchia, family Aetosauridae. Upper Triassic, Cynognathus zone, Burghersdorp beds, Cape Colony, South Africa. Natural size. After Broom.
44. *Camptosaurus*. Order Ornithischia, suborder Iguanodontia, family Camptosauridae. Upper Jurassic, Morrison Formation, Wyoming. Composite restoration, after Gilmore. $\times \frac{1}{2}$. sq, supraorbital (anterior), a.o.f., antorbital fenestra.
45. *Gryposaurus* (= *Kritosaurus*) *notabilis*. Order Ornithischia, suborder Iguanodontia, family Trachodontidae. Upper Cretaceous, Belly River formation, Alberta, Canada. After Lambe.
46. *Triceratops flabellatus*. Order Ornithischia, suborder Ceratopsia, family Ceratopsidae, Late Cretaceous, Lance Creek beds, Converse Co., Wyoming. After Hatcher.

the prefrontal, maxilla, and jugal (*op. cit.*, p. 234). As in *Camptosaurus*, the lacrymal is surmounted by a divergent presupraorbital bone.

In *Stegosaurus*, as figured by Gilmore (1914, Pl. v), the antorbital fenestra has been obliterated by the secondary spreading of the lacrymal, nasal, and ascending process of the maxilla. In general, the *Stegosaurus* face is closely related in its construction to that of *Iguanodon*.

In *Trachodon* the anterior nares are greatly enlarged, extending back to the lacrymals without, however, disturbing the primitive ornithischian relations of the lacrymal.

In the highly specialized crested trachodonts (figured by Brown and by Lambe) the nasal cavity is enlarged and prolonged backward on to the top of the skull, so that the premaxillæ and nasals extend far backward and upward; to some degree recalling the condition in the odontocetes among mammals. But, in spite of this, the lacrymal retains much of its primitive ornithischian position and connections. *Gryposaurus* (= *Kritosaurus*) *notabilis* Lambe (Fig. 45) shows the initial stage in the dorsal growth of the nasal region. Here the lacrymal is in contact with the prefrontal, premaxilla, maxilla, and jugal, as in the primitive *Camptosaurus*, but the presupraorbital bone appears to be absent. In *Stephanosaurus* (cf. Lambe, April 1914, Pl. 1), and still more in *Corythosaurus* Brown, the extraordinary enlargement and dorsal growth of the nasal chamber has conditioned a great expansion of the prefrontal, which covers the side of this chamber and now separates the lacrymal from the premaxilla.

In the Ceratopsia the lacrymal forms the stout anterior rim of the orbit and, together with the prefrontal bone, it transmits stresses from the postorbital horns downward to the stout jugal, forward to the nasal, and both downward and forward to the maxilla. In front of the wide jugo-lacrymal junction is a narrow fissure, directed forward and downward and located just below the narrow ascending process of the maxilla. On comparing this fissure in *Triceratops* (Fig. 46) with the homologous opening in *Monoclonius* and other ceratopsians and trachodonts, it appears to represent a vestige of the antorbital fenestra, lying between the maxilla and the lacrymal. In the relatively primitive *Brachyceratops montanus* Gilmore (1917, p. 15) the fissure in question is large and lies between the ascending and the jugal processes of the maxilla, exactly as does the small antorbital vacuity of *Camptosaurus*. The fissure is nearly

obliterated in *Stephanosaurus* and *Corythosaurus*, where it has no appearance of transmitting either nerves or blood vessels.¹

In conclusion, the pattern of the facial elements in the whole ornithischian series appears to be derived from the primitive fenestrate type represented by *Aëtosaurus*, *Ornithosuchus*, and *Euparkeria*, a result which is in harmony with the fact that the pelvis of *Euparkeria* distinctly foreshadows the ornithischian type.

In pterosaurs the anterior nares are extended dorsad and the premaxillæ have long ascending processes which articulate with the frontals between the enlarged prefrontals (called "lacrymals" by von Huene, 1914). The lacrymals, as shown in the skull of *Scaphognathus* figured by E. T. Newton (1888, Pls. LXXVII, LXXVIII), bound the large antorbital fenestræ dorsoposteriorly and are in contact below with the jugals. The elements which are interpreted as nasals by both Newton and von Huene are long, narrow strips which are lateral to the prefrontals.

According to von Huene (1913, p. 60) there is a separate supra-orbital, clearly defined by sutures on both sides, on the anterosuperior margin of the orbit. In the more specialized genus *Nyctosaurus*, as figured by Williston (1902) and von Huene (1914), the nares are confluent with the enlarged antorbital fenestræ and the lacrymals are fused with the prefrontals. According to von Huene there is also a supra-orbital bone. The nasals are greatly abbreviated.

As thus described, the circumorbital region of pterosaurs might perhaps be derived from the conditions figured in the aëtosaurian genus *Euparkeria* (Fig. 43), except for the anomalous position of the supposed nasals, which are chiefly lateral to the prefrontal. Newton and von Huene have noted the general resemblance of the orbital region of pterosaurs to that of birds.

Birds

In the whole class of birds the prefrontal is enlarged (Fig. 51) and simulates a mammalian lacrymal, since it transmits the lacrymal duct and is located at the anterosuperior quarter of the orbit. Hence it has often been called "lacrymal." Von Huene (1914, p. 61) regards the

¹For this reason, I would doubt the interpretation of this fissure as either an infraorbital foramen (Hatcher, Marsh, Lull, 1907, pp. 26, 27) or as a "lacrymal foramen" (*op. cit.*, Pls. xxxii, xxxiv, xlv). The real homologue of the mammalian infraorbital foramen, according to Gaupp (1910), is the longitudinal series of foramina in the maxilla of recent reptiles, opening on the face above the tooth-row. These are named by Gaupp "foramina maxillo-facialia." They serve for the transmission of twigs of the maxillary nerve. A similar row or rows of vessels is present in the maxilla of many dinosaurs of both orders; they are very plain in the Ceratopsia and in the trachodonts. The fissure in question can hardly be the ductus naso-lacrymalis, which must lead from the orbit to the interior of the nasal chamber at a deep level, instead of opening in front on the side of the face.

upper part of this element as the homologue of the reptilian supraorbital. This identification may eventually be confirmed, especially in view of the general similarity of the dorsal part of the element in question to the true supraorbital of primitive ornithischian dinosaurs (Fig. 44). Nevertheless, in early stages of development, this bone, in struthious and other birds, has more the appearance of a true reptilian prefrontal, as shown in the figures by W. K. Parker (1869), T. J. Parker (1891), and Pycraft (1900). I, therefore, provisionally identify it as prefrontal rather than as lacrymal or as supraorbital.

Rhynchocephalida, Parapsida

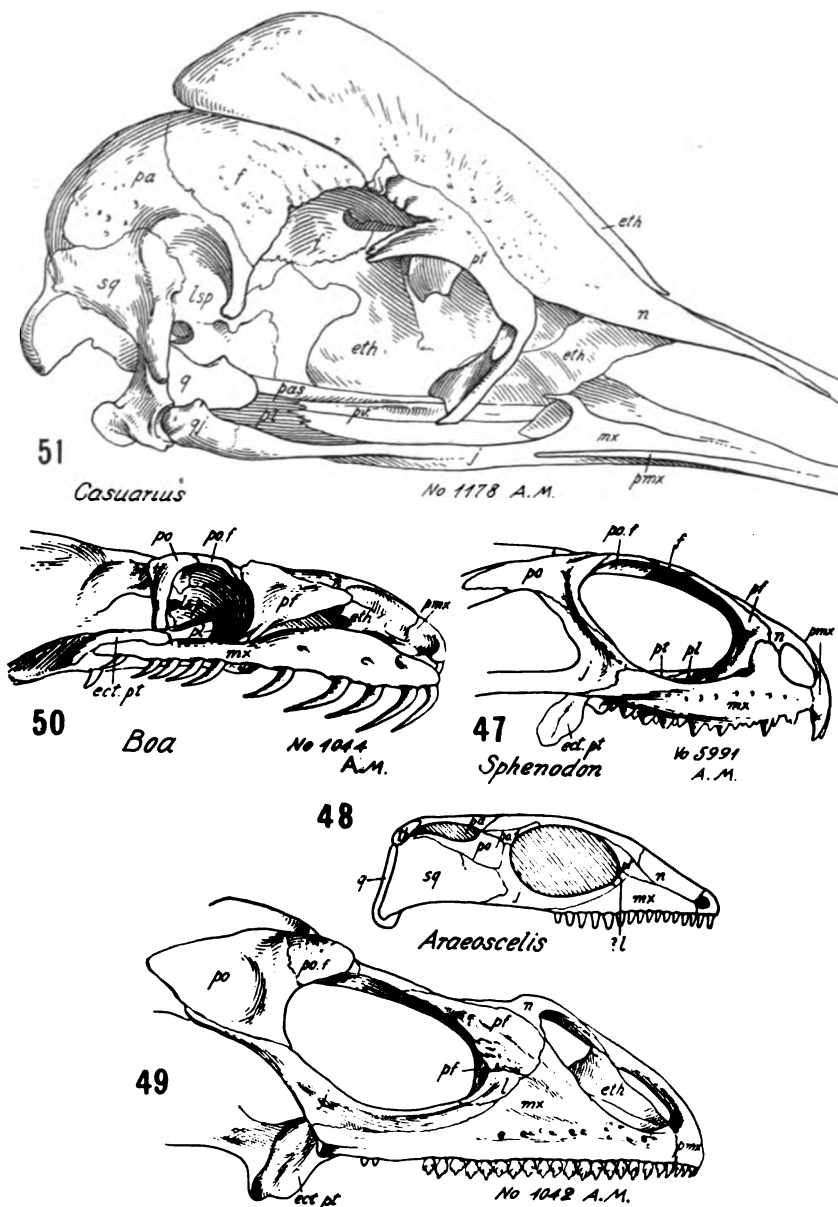
In the Triassic rhynchosaurian genus *Hyperodapedon*, according to Burckhardt (1900), a small lacrymal is present. It is separated from the prefrontal by the posterior tip of the enlarged premaxilla. In the allied *Stenomelopon* Boulenger (1903), the prefrontal alone forms the anterior brace between the enlarged maxilla and the frontals and the lacrymal is absent. Essentially similar conditions appear in the modern *Sphenodon* (Fig. 47). Here, as in so many other reptiles, the prefrontal is enlarged, forms the anterior brace of the orbit, and is in contact below with the palatine. It thus parallels in position and function the parethmoid of fishes. The lacrymal foramen lies between the prefrontal and the maxilla.

In *Champsosaurus*, of the group called Choristodera, the prefrontal shares in the elongation of the snout. A fair sized lacrymal is present, in contact with the prefrontal, maxilla, and jugal (Brown, 1905, Pl. III).

In *Palæohatteria* Credner, which Williston was inclined to relate to the Protorosauria and Squamata, the lacrymal, according to Credner's figures (1888, Pl. xxv), was of fairly primitive type, retaining its normal contacts with the prefrontal, nasal, maxilla, and jugal. According to Credner's Fig. 3, Pl. xxv, the lacrymal was just excluded from the orbital rim by a slight prefrontal-jugal contact.

In *Aræoscelis* Williston (Fig. 48), of the American Permian, enlargement of the orbit is associated with an apparent reduction of the lacrymal, the prefrontal usurping its contact with the nasal.

In *Sauranodon* and *Pleurosaurus* Lortet's plates show that the prefrontal was enlarged and probably the lacrymal was small or wanting. Watson (1914) states that in *Pleurosaurus* the lacrymal is a very small bone forming a part of the orbital boundary and wedged in between the prefrontal and maxilla. These reptiles were formerly referred to the Rhynchocephalia, but Boulenger, Watson and Williston have advanced cogent objections to this view and they are referred by Watson to the suborder Acrosauria von Meyer, of the order Squamata.



Figs. 47 to 51. Skulls of various Sauropsida showing reduction or absence of the lacrymal and its replacement by the prefrontal.

47. *Sphenodon (Hatteria) punctata*. Class Reptilia, series Rhynchocephalida, order Rhynchocephalia, family Sphenodontidae.
48. *Araeoscelis gracilis*. Class Reptilia, series Parapsida, order Squamata (?), suborder Araeoscelidia (?Protorosauria), family Araeoscelidae. Permo-Carboniferous, Clear Fork, Texas.
49. *Cyclura cornuta*. Class Reptilia, series Parapsida, order Squamata, suborder Sauria, family Iguanidae.
50. *Boa constrictor*. Class Reptilia, series Parapsida, order Squamata, suborder Ophidia, section Aglypha, family Boidae.
51. *Casuarius* sp. Class Aves, subclass Ornithura, order Megistaneae, family Dromaeidae. Immature skull with many open sutures.

In many of the recent lizards (Fig. 49) the lacrymal is reduced sometimes to a vestige, while the enlarged prefrontal crowds it away from the nasals and partly appropriates the naso-lacrymal duct. As already noted, Gaupp (1910) emphasized the fact that in *Lacerta* the enlarged prefrontal overlaps the cartilaginous nasal capsule laterally and is medial to the naso-lacrymal duct. In these characters it agrees with the mammalian lacrymal, with which Gaupp homologized it. It also has other topographic relations often seen in mammalian lacrymals, namely, it articulates above with the frontal, below with the palatine, and in front with the enlarged maxilla; in *Lacerta* it is also separated from the nasal by the junction of the maxillary process of the frontal with the frontal process of the maxilla, as is the lacrymal in many mammals. In Iguanids the enlarged prefrontal is in wide contact with the nasals as it is in the anomodonts.

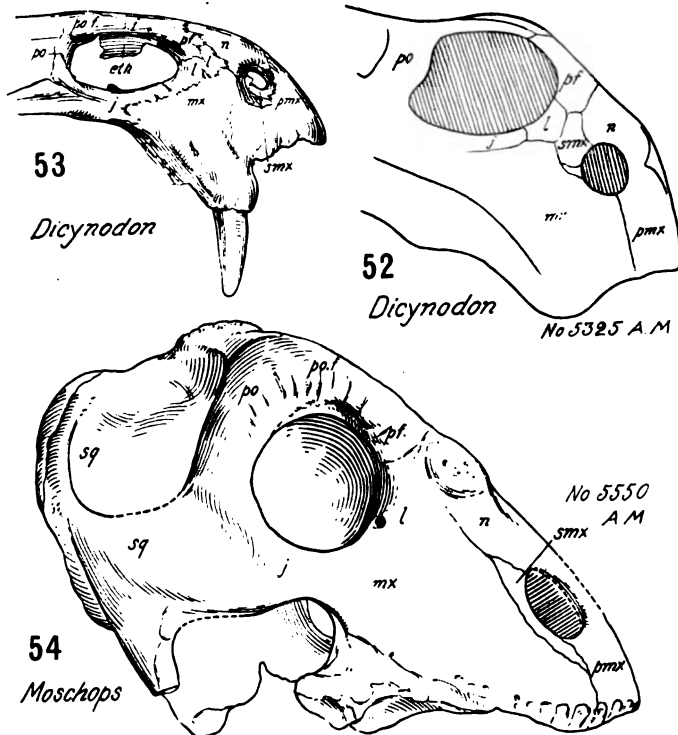
Nevertheless, it is highly probable that these resemblances are largely due to convergence, because a comprehensive review of the whole anatomy of lizards shows that they are genetically very far removed from the ancestors of the mammals, in contrast with the Therapsida, which finally approach the mammals in every part of the skeleton and in which there seems to be no room for doubt that the lacrymal, and not the prefrontal, is homologous with that of mammals.

The predominance of the prefrontals over the lacrymals, which is less marked in the monitors, attains its logical extreme in the snakes (Fig. 49), in which the lacrymal is entirely wanting.

THE LACRYMAL REGION IN THE THERAPSID REPTILES

The Therapsida (Figs. 52 and 57) are sharply distinguished from the more primitive Permian reptiles by the relatively small anterior extension of the lacrymal, which is overgrown anteriorly by a large ascending flange of the maxilla. Originally in this order the skull may have been short and the orbit located nearly half-way between the tip of the nose and the occiput, as it is in the Dromasauria and in the more primitive of the Dinocephalia. In the Dromasauria the lacrymal is crowded between the very large orbit and the enlarged maxilla; it is, however, in contact anteriorly with the septomaxilla and separates the maxilla from the nasals (Broom, 1914). Similar conditions prevail in the anomodont *Dicynodon* (Fig. 52). Here, according to Broom (1912, pp. 342, 343) the "lacrymal has a comparatively small facial portion, though it forms a considerably larger part of the inner wall of the orbit." Broom also notes the presence of a lacrymal foramen which, he states, is rather large and lies inside the orbit.

The most detailed and complete description of the lacrymal region of an anomodont is that by Igerna B. J., and W. J. Sollas (1913-1916) in their accounts of the structure of the skull of *Dicynodon* (Fig. 53), based on serial sections. The lacrymal contributes a vaulted lamina to



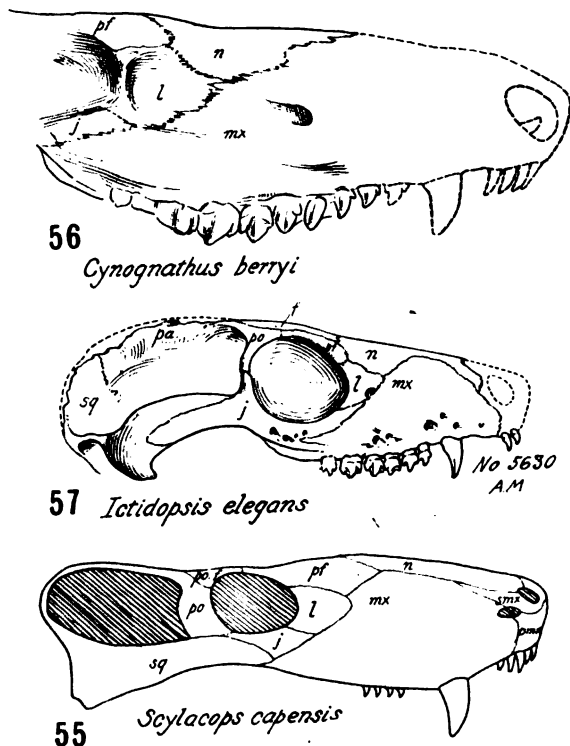
Figs. 52 to 54. Skulls of a Dinocephalian and two Anomodonts. Class Reptilia, series Synapsida, order Therapsida.

52. *Dicynodon moschops*. Suborder Anomodontia, family Dicynodontidae. Endothiodon zone, Beaufort beds of the Karroo system, Graaf Reinet district, Cape Colony, South Africa. After Broom.
53. *Dicynodon leoniceps*. Suborder Anomodontia, family Dicynodontidae. Middle Permian, Pariaasaurus zone, Beaufort beds, Karroo system (from the Gouph district) Cape Colony, South Africa. After I. B. J. and W. J. Sollas.
54. *Moschops capensis*. Suborder Dinocephalia, family Tapinocephalidae. Lower (?) Permian, "Horison, not improbably Upper Ecca series." R. Broom. Karroo System, Cape Colony, South Africa.

the outer wall of the chamber surrounding the tusk. This vaulted lamina meets the prefrontal and is overlapped by the nasal, while its thickened outer wall is penetrated by the lacrymal duct, which leads downward and forward, opening into the nasal cavity (*op. cit.*, 1916, Pl. xxxvi,

fig. 7). The facial part of the lacrymal is in contact with the jugal, maxilla, nasal, and prefrontal.

Among the Dinocephalia, as figured by Broom and Watson, the lacrymal is in contact above with the nasal and prefrontal and below



Figs. 55 to 57. Skulls of a Gorgonopsian and two Cynodonts. Class Reptilia, series Synapsida, order Therapsida.

55. *Scylacops capensis*. Suborder Gorgonopsia, family Gorgonopsidae. Upper Permian, Cistecephalus zone, Beaufort beds, Cape Colony, South Africa. After Broom. $\times \frac{1}{4}$.
 56. *Cynognathus berryi*. Suborder Cynodontia, family Galeosauridae. Upper Triassic, Cynognathus zone, Upper Beaufort beds, Lady Mere, Cape Colony, South Africa. After Seeley, somewhat modified.
 57. *Ictidopsis elegans*. Suborder Cynodontia, family Galeosauridae. Upper Triassic, Cynognathus zone, Upper Beaufort beds, Harrismith, Orange River Colony, South Africa. Natural size.

with the maxilla and the jugal. The ascending flange of the maxilla is well developed, restricting the facial portion of the lacrymal anteriorly, separating the lacrymal from the extended septomaxilla and gaining contact between these two elements with the nasal. In the type of *Moschops capensis* Broom (Amer. Mus. No. 5550, Fig. 54) the lacrymal

is perforated on both sides of the skull by a large duct which opens on the face immediately in front of the orbit. In another skull of *Moschops*, however, this foramen is not visible.

In the Gorgonopsia (Fig. 55) the face is perhaps secondarily elongated, the vertical flange of the maxillary is greatly enlarged and deepened and the ascending process articulates with the prefrontal and covers the pars facialis of the lacrymal anteriorly. The prefrontal is large and separates the lacrymal from the nasal.

The lacrymal of the therocephalian *Lycosuchus vanderrieti* has been thus described by Broom (1902, p. 198): "The lachrymal is considerably shorter than the prefrontal, and fits in between the prefrontal, the maxillary, and the jugal. It has apparently only a single lachrymal canal, well within the orbit."

The lacrymal region of the Cynodontia has been noticed of late years especially by Broom (1911, 1914), Watson (1911)¹ and Haughton (1918). Broom states that in *Gomphognathus minor* the lacrymal forms the front of the orbit and much of its inner wall. In *G. polyphagus* it is considerably larger, extending to part of the upper margin of the orbit, almost as in primitive marsupials. In this species, also, the prefrontal is smaller than in others. The lacrymal in these forms, as well as in *Cynognathus* (Fig. 56), has a wide contact with the nasal. The lacrymal is especially well shown in the type of *Ictidopsis elegans* Broom (Amer. Mus. No. 5630), as in Fig. 57. The naso-lacrymal contact is wide and the facial part of the lacrymal is overlapped in front by the high ascending flange of the maxilla. A small lacrymal foramen lies immediately behind the lacrymo-maxillary junction. Possibly the latter may be homologous with the lateral lacrymal foramen of *Thylacinus*, the former with the medial lacrymal foramen of the same genus (Fig. 70.)

In *Cynosuchus whaitsi* Haughton, a very primitive cynodont from the Lower Beaufort Beds, structurally ancestral to *Diademodon*, the lacrymal forms most of the anterior border of the orbit and is in contact with the spreading nasal. "It is pierced just behind its suture with the maxilla by the lacrymal foramen, which communicates by a short canal through the bone with a foramen within the orbit. Within the orbit there is also another smaller foramen above the one referred to" (Haughton, 1918, p. 199). Haughton notes that the palatine of this remarkably mammal-like reptile is mainly a vertical bone; but it is not stated whether the palatine was in contact with the lacrymal on the inner wall of the orbit.

¹See addendum, p. 263.

Thus the Therapsida afford strong evidence for the traditional, or "Cuvierian," view that it is the lower of the two preorbital bones and not the upper, which is the homologue of the mammalian lacrymal. In the older and presumably more primitive Therapsida, such as the Therocephalia and the Gorgonopsia, the prefrontal is larger than the lacrymal, but in the cynodonts, which in all other characters approach the mammals, the lacrymal has increased in size, is pierced by the lacrymal canal and, like the lacrymal of primitive mammals, has firm contact with the jugal, the maxilla, and the nasal.

THE TRANSITION FROM REPTILIAN TO MAMMALIAN CONDITIONS

Owing to the imperfection of the palæontological record, the long ages of the Mesozoic yield but little direct palæontologic evidence as to the final emergence of the mammals from the therapsid stem and the subsequent modernization of the mammalian skull. On very sound and abundant morphological and physiological evidence it is believed, however, that the acquirement of a higher body temperature involved improved respiration, improved circulation and glandular activity, improved heat-conserving and heat-regulating structures, and above all a greatly advanced central nervous system—all of which doubtless conditioned the observed differences between cynodonts and mammals. In the facial region the cynodonts differ from the mammals chiefly in the retention of the prefrontal and postorbital bones. These doubtless dwindled and disappeared, along with several other elements of the skull, as the mammalian grade of organization was approached.

When the ascending ramus of the dentary became so large that it began to press down part of the temporal muscle-mass into a bursa or interarticular disc,¹ the diminishing quadrate and articular bones increased their auditory functions and their jaw-suspending function. Soon afterward the prefrontal and the postorbital probably disappeared² and the lacrymal and the maxilla came to form the sole anterior brace for the zygomatic arch.

One of the great advances connected with this general transformation of poecilotheal reptiles into homœothermal mammals was the differentiation and spreading of the sphincter colli muscles. These,

¹According to B. Petronievics (1919, pp. 200-203) there is an "incipient condylar process" on the dentary of *Gomphognathus*, which possibly articulated with a "flat surface on the squamosal" behind it and thus either closely approximated to, or even fully exemplified, an early stage in the evolution of a "temporo-mandibular" joint like that of mammals.

²Dr. J. L. Wortman (1920, pp. 1-52) records the occurrence of "prefrontal," "postorbital," "quadrato-jugal," "quadrate" and other "reptilian elements" in the skulls of several modern mammals; but, for reasons which will be set forth elsewhere, I doubt the correctness of his identifications.

as Ruge (1897) has shown, invaded the facial region, carrying with them their primitive nerve, the facialis and its branches, and giving rise to the highly characteristic platysma group, or mimetic muscles, around the eyes, nose, and mouth. The lacrymal bone soon came into functional relations with some of these muscles, which henceforth exert considerable influence upon its subsequent evolution. Perhaps even in the therapsids (cynodonts) the ligament of the eyelids (*ligamentum tarsale sive palpebrale*) at the inner canthus of the eye may have been attached to the lacrymal bone, just above the orbital opening of the lacrymal duct. In primitive mammals the site of this attachment is marked by the lacrymal spine, or tubercle, while the preorbicularis dorsalis and ventralis muscles cover the facial surface of the lacrymal and are more or less connected with it by fascia. The inner surface of the lacrymal, especially the pars orbitalis, takes part with the frontals in separating the eye and its muscles from the ethmoid region. The lower part of the pars orbitalis articulates with the vertical plate of the palatine.

Through the loss of the prefrontal the lacrymal of mammals has acquired a wide contact with the frontal on the inner wall of the orbit and this contact is apparently never lost. In such primitive mammals as the opossum, which have stout zygomatic arches, the lacrymal serves as a keystone between the whole upper jaw and temporal arch on the one hand and the dermal skull roof on the other, as anyone may realize who will try to spring apart an opossum skull along the naso-maxillary junction. The lacrymal of mammals often articulates with the nasals; sometimes this contact appears to be secondary, but in certain marsupials it may well have been inherited from a cynodont ancestor. The lacrymal usually retains its primitive relations with the palatine, jugal, and maxillary, as well as with the naso-lacrymal duct. The latter is usually covered by a bony tube which primitively runs forward from the lacrymal along the inner wall of the maxillary and opens near the front end of the nasal cavity beneath the lower maxillo-turbinal.

Thus it will readily be seen that the lacrymal of mammals has relations with a considerable number of surrounding elements and that the course of its evolution has doubtless been influenced by changes in each one of these elements, as will be made clear on subsequent pages.

THE LACRYMAL REGION IN ALLOTHERIA, MONOTREMES AND MARSUPIALS

Allotheria

The oldest known mammal of which the lacrymal region is known is *Tritylodon longævus* (Fig. 58) of the Lower Jurassic of South Africa, which Dr. Broom (1910) believes to be a multituberculate.¹ According to Broom, the lacrymal of this animal is a large element forming the anterior rim of the orbit and with a large preorbital extension. It articulates above with the very wide nasal, in front with the ascending lamina of the maxillary, and below with the stout jugal; it also extends widely on the inner wall of the orbit. Thus it resembles the lacrymal of *Gomphognathus* among the cynodonts in all its relations, except that it does not articulate with the prefrontal, which is lacking.

The Paleocene *Polymastodon taoensis* (Figs. 59, 60), as described by Broom (1914), has extremely wide nasals and small frontals, as in cynodonts, *Tritylodon*, *Ornithorhynchus*, and recent marsupials. The anterior orbital rim is formed, not by the lacrymal, which seems to be wanting, but by the enlarged maxilla, which meets the nasal above the orbit. The parietals send forward narrow processes which completely exclude the frontals from the orbit and even meet the nasals and maxillæ above it. These extraordinary conditions, which may readily be verified on the specimen Amer. Mus. No. 16321, are cited by Dr. Broom as evidence of remote relationship with the monotremes, along with the great reduction of the jugal and the supposed disappearance of the lacrymal.

Monotremata

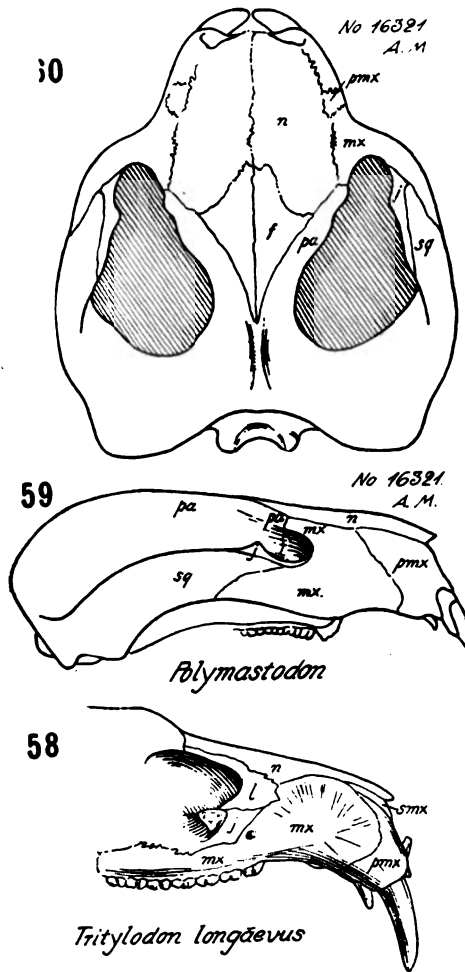
In the living monotremes (Figs. 61, 62) the lacrymal is absent.

Marsupialia

It has long been realized that the existing marsupials probably represent the survivors of an early and pre-placental adaptive radiation, beginning possibly as far back as the Jurassic and extending perhaps in the Cretaceous to Australia.

It has also been held by Huxley, Dollo, Bensley, and others, on morphological grounds, that the opossums represent in many but not all characters the little modified stem forms of the whole group—a conclusion which is further supported by the discovery of primitive

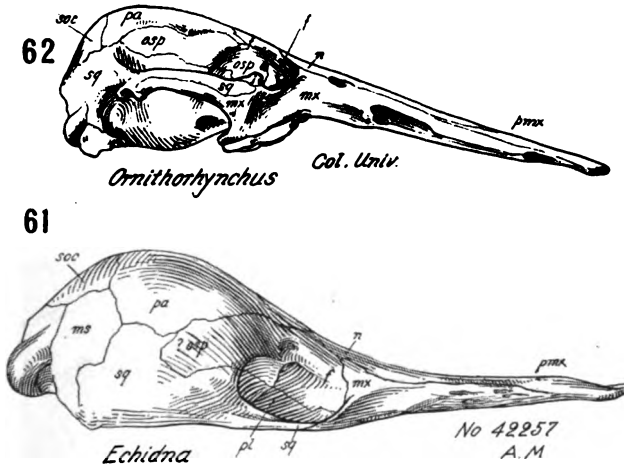
¹At first sight one might feel that there is still some justification for Seeley's view that *Tritylodon* was related to the gomphodont cynodonts. In *Trirachodon kannemeyeri* the lower canines become greatly elongate and pass upward into deep sockets in the upper jaw, the whole suggesting the relation of the enlarged upper and lower front teeth of *Tritylodon*. An important objection to this view, however, is that, according to Broom, the enlarged upper front teeth of *Tritylodon* are borne by the premaxillæ, while in *Trirachodon* they are certainly borne by the maxillæ.



Figs. 58 to 60. Skulls of *Tritylodon* and *Polymastodon*. Class Mammalia.

58. *Tritylodon longævus*. Subclass Prototheria, (?), order Multituberculata, family Tritylodontidae. Lower Jurassic, Stormberg beds, Basutoland, South Africa. After Broom.
59. *Polymastodon taensis*. Subclass Paurotheria (?), order Multituberculata, family Plagiaulacidae. Paleocene, Polymastodon zone, Puerco formation, Ojo Alamo, New Mexico. After Broom.
60. *Polymastodon taensis*. Dorsal view of skull. After Broom.

opossums in the Upper Cretaceous of North America (Matthew, 1916). Unfortunately, the lacrymal region of the type of *Eodelphis browni* Matthew is not known. The recent opossums are also noteworthy in the present connection because they retain many characters which may well be regarded as a direct heritage from primitive cynodonts. One of these is the wide-spreading nasals (Fig. 63) and another is the form of the



Figs. 61 to 62. Skulls of Monotremes. Class Mammalia, subclass Prototheria, order Monotremata.

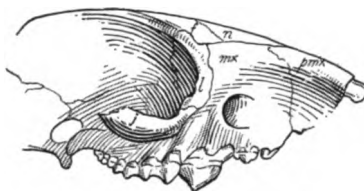
61. *Echidna* (= *Tachyglauus*) sp. Family Echidnidae. Young skull showing sutures.

62. *Ornithorhynchus*. Family Ornithorhynchidae. Sutures restored after Watson and van Bemmel.

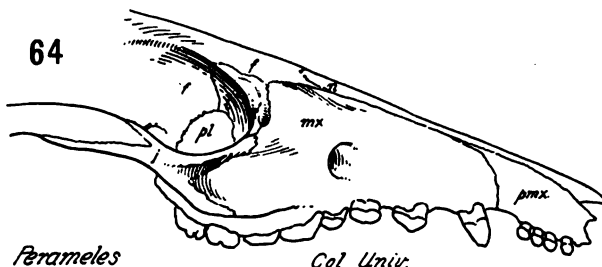
maxillary bone as seen from the outside, as it curves upward toward the nasals. In *Didelphis*, *Chironectes*, *Marmosa*, and other opossums this ascending blade of the maxilla is not so much developed posteriorly as it is in most mammals, so that it gains only a narrow and rather variable contact with the frontals, in contrast with the wide fronto-maxillary contact of primitive placentals. Beneath the frontal process of the maxilla the lacrymal often nearly or quite reaches the widely spreading nasals, a condition which may be a remnant of the wide lacrymo-nasal contact of the cynodonts. The lacrymal of the opossums is extended dorsally toward the superior border of the orbit but is not so distinctly rimmed above as it is in most marsupials. The pars facialis is rather small and the large lacrymal foramen is marginal, as it is in many marsupials.

Among the Borhyænidae of the Santa Cruz formation perhaps the most primitive conditions are preserved in the genus *Amphiproviverra*

65

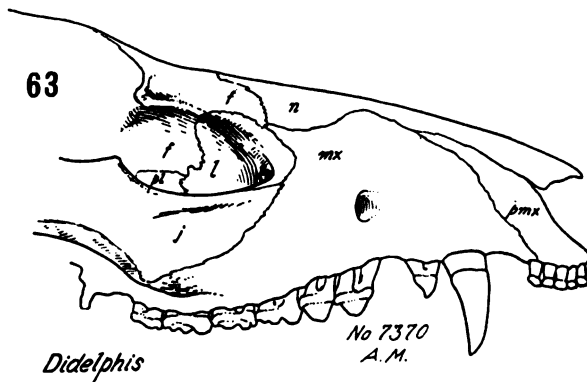
*Palaeothentes intermedius*

64

*Perameles*

Col Univ.

63

*Didelphis*No 7370
A. M.

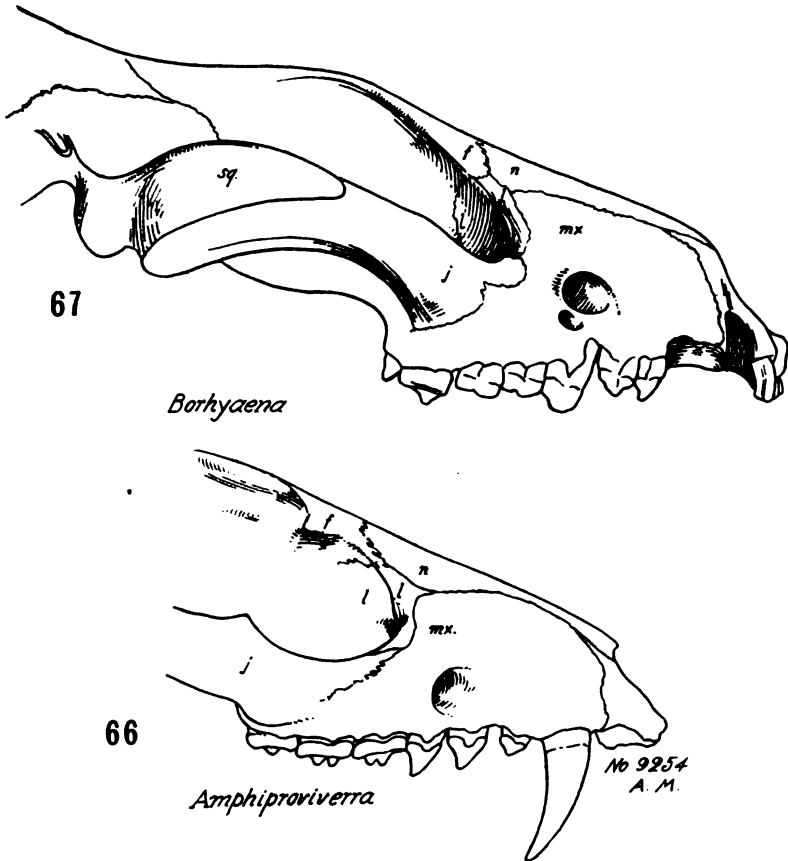
Figs. 63 to 65. Skulls of Polyprotodont Marsupials. Class Mammalia, sub-class Metatheria, order Marsupialia, suborder Polyprotodontia.

63. *Didelphis virginiana*. Family Didelphyidae.

64. *Perameles* sp. Family Peramelidae.

65. *Palaeothentes intermedius*. Family Palaeothentidae (Epanorthidae). Middle (?) Miocene, Santa Cruz Formation, Patagonia. After Sinclair.

(Fig. 66); here the lacrymal differs from that of *Dasyurus* in that it has a more prominent orbital rim and a larger pars facialis, which is in wide contact with the spreading nasals. The foramen is within the antorbital border. In *Borhyaena* the pars facialis is of small to moderate size. In *B. tuberata* (Fig. 67) there is a wide naso-lacrymal contact (Sinclair,

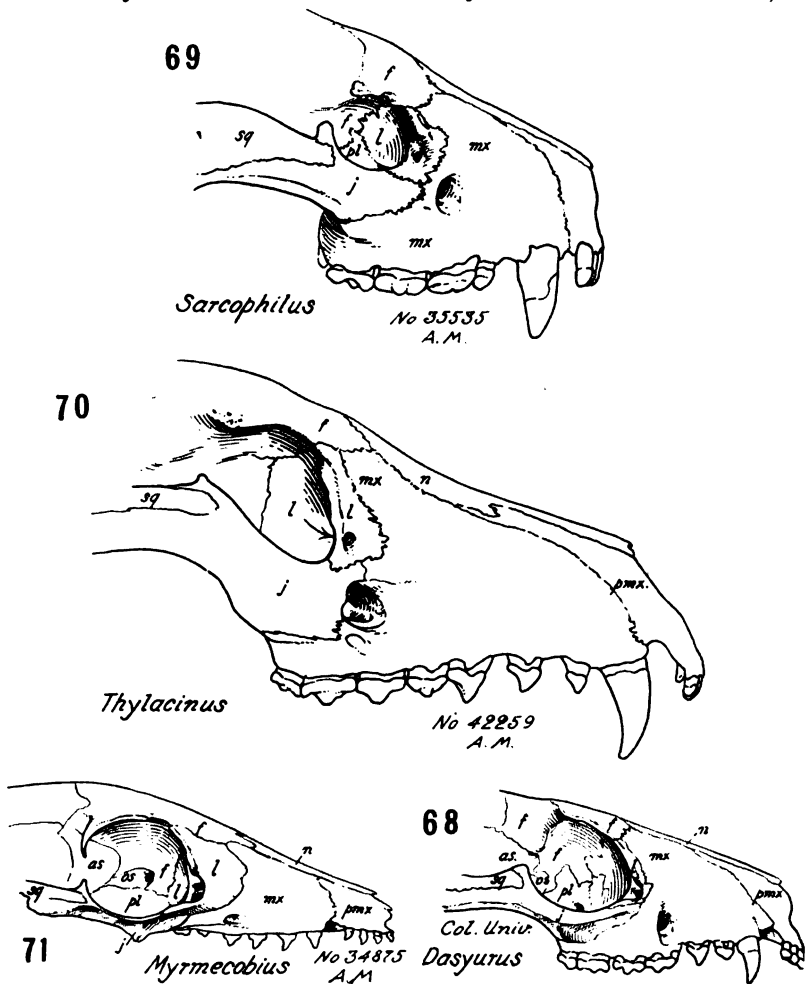


Figs. 66 to 67. Skulls of Polyprotodonts (continued).

66. *Amphiprioniverra* sp. Family Borhyaenidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.
 67. *Borhyaena tuberata*. Family Borhyaenidae. Middle (?) Miocene, Santa Cruz formation, Patagonia. After Sinclair.

1901, Pl. XL) but in *B. excavata* the tip of the maxilla just reaches the frontals and slightly separates the nasals from the lacrymals (idem, Pl. XLV).

In *Dasyurus* (Fig. 68) the lacrymal rim is continuous with the superior border of the orbit. In *Sarcophilus* (Fig. 69), in which the skull is extremely robust and the muzzle very coarse but rather short, the



Figs. 68 to 71. Skulls of Polyprotodont Marsupials (continued).

68. *Dasyurus viverrinus*. Family Dasyuridae, subfamily Dasyurinae.
 69. *Sarcophilus ursinus*. Family Dasyuridae, subfamily Dasyurinae.
 70. *Thylacinus cynocephalus*. Family Dasyuridae, subfamily Dasyurinae.
 71. *Myrmecobius fasciatus*. Family Dasyuridae, subfamily Myrmecobiinae.

lacrymal is of moderate size and has but a moderate extension on the face. The lacrymal foramen is external, on the pars facialis immediately in front of the orbit. In the long-faced *Thylacinus* (Fig. 70) the facial

part of the lacrymal is extended. The lacrymal is expanded superiorly and bears a prominent orbital rim. The main foramen is internal to the rim, but there is another foramen on the pars facialis which leads straight inward to the lacrymal duct. This outer foramen may well be homologous with the single foramen of *Sarcophilus*.

In *Perameles* (Fig. 64) the conformation of the lacrymal region is evidently related to the typical condition of the Dasyuridæ. Although the snout is elongate, the facial part of the lacrymal is very small. The narrow nasals are widely separated from the lacrymals by the wide maxillo-frontal contact. The ethmoid scrolls are expanded and so is the maxillary antrum.

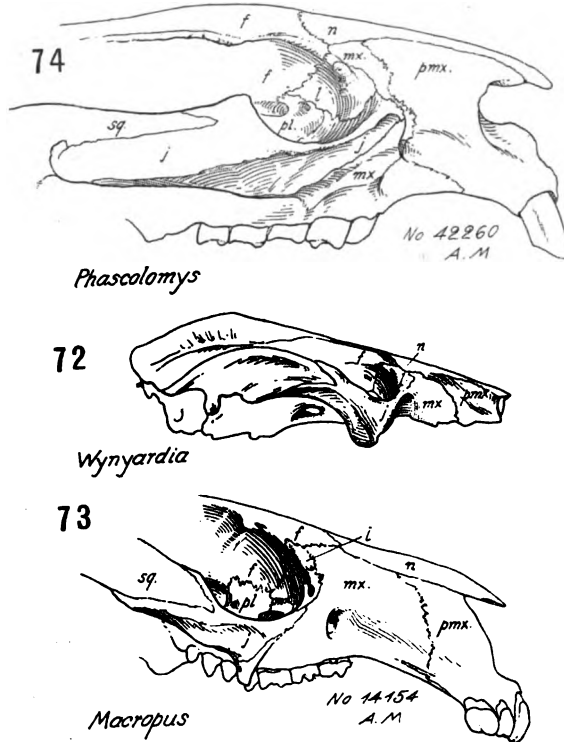
Myrmecobius (Fig. 71) has sometimes been regarded as related in a very special way to the Mesozoic mammals and Wortman (1903, p. 407) assumes that its lacrymal region is primitive. The whole snout is tubular, the ethmoid folds are expanded, and in correlation with this the frontals are widely expanded anteriorly, pushing the lacrymals outward upon the zygomatic arches. The lacrymals are also inflated, as they are in the Menotyphla and other forms with similar construction of the snout and ethmoid region. The pars facialis, as in all such forms, is extended. The dorso-anterior orbital rim of the lacrymal is unusually well developed. The foramen occupies its primitive position behind the antorbital rim. From a study of the basicranial region and other parts of the skull, the writer would endorse the conclusion of Bensley (1903) that *Myrmecobius* is only a specialized dasyurid. Hence its lacrymal region is not as primitive as it is in *Dasyurus*.

Among the diprotodonts perhaps the most primitive construction of the lacrymal region is seen in the early Tertiary genus *Wynyardia* (Fig. 72) of Baldwin Spencer (1900, Pl. L). The lacrymal is extended dorsally over the orbital surface of the frontal and is in contact with the nasal, excluding the maxilla from contact with the frontal. It has a prominent orbital rim and the pars facialis is short. The foramen is located on the pars facialis on the edge of the orbital rim.

Similar types of lacrymal are seen in the modern phalangers and their allies and in the Macropodidæ (Fig. 73). The maxillo-frontal contact varies in extent, but is well developed in the Macropodidæ. In *Halmaturus* the beautiful dissections of Boas and Paulli (1908, Pl. XIII) show that the orbital tubercle, or rim, serves dorsally for the attachment of the fascia covering the temporal mass and ventrally for the attachment of the palpebral ligament. The facial muscles are less differentiated than in placental mammals and clearly suggest their connection with the

platysma muscle. This furnishes additional evidence of primitive conditions in the lacrymal region of marsupials.

In the beaver-like *Phascolomys* (Fig. 74) the great enlargement of the anterior part of the masseter muscle and the consequent outgrowth and dorsal shifting of the anterior part of the zygomatic arch has crowded the lacrymal dorsad and conditioned its reduction in size. The tubercle



Figs. 72 to 74. Skulls of Diprotodont Marsupials. Class Mammalia, subclass Metatheria, order Marsupialia, suborder Diprotodontia.

72. *Wynyardia bassiana*. Family uncertain. Tertiary of Table Cape, Tasmania. After Baldwin Spencer.

73. *Macropus* sp. Family Macropodidae.

74. *Phascolomys ursinus*. Family Phascolomyidae.

for the attachment of the palpebral ligament is exceptionally prominent. There is a wide contact with the extremely wide nasals.

The lacrymal region of *Cænolestes* is well shown in two skulls kindly loaned by Dr. W. H. Osgood (Field Mus. Nos. 18602, 18605). In general, the nearest resemblance is with *Perameles*, but the lacrymal is smaller

and has a less well defined orbital crest. The foramen is marginal. The lacrymal is widely separated from the nasals by the maxillo-frontal contact.

In *Palæothentes intermedius* (Fig. 65) of the Santa Cruz formation (Sinclair, 1901, Pl. LXIII, fig. 3) the lacrymal is extended vertically, forming a prominent antorbital rim. It is in contact with the jugal below, with the maxilla in front and with the frontal above; it is separated from the spreading nasal by the fronto-maxillary contact. The lacrymal of *Palæothentes* is thus distinctly more primitive than that of *Cænolestes*, as it is more extended dorsally and forms a more projecting antorbital rim; it also retains a little of the pars facialis near the upper end.

Thus the marsupials as a whole are characterized by the somewhat primitive condition of the lacrymal, which is expanded dorsally, bears a prominent orbital rim and primitively has a small or moderate pre-orbital extension; the foramen is primitively marginal but a second extra-orbital foramen may be present. The fronto-maxillary contact, very small in many opossums, is well developed in many advanced types. The proximal ends of the nasals spread widely and are often in contact with the lacrymals. The primitive contacts with the frontal, maxillary, and jugal are retained; contact with the orbital plate of the palatine, although retained in *Didelphis*, *Sarcophilus*, *Thylacinus*, and *Amphiprovierra*, was replaced by a maxillo-palatine contact in *Phalangista*, *Bettongia*, *Halmaturus*, and *Phascolumys*.

THE LACRYMAL REGION IN THE PLACENTAL ORDERS OF THE PALEOCENE, EOCENE, AND LATER EPOCHS

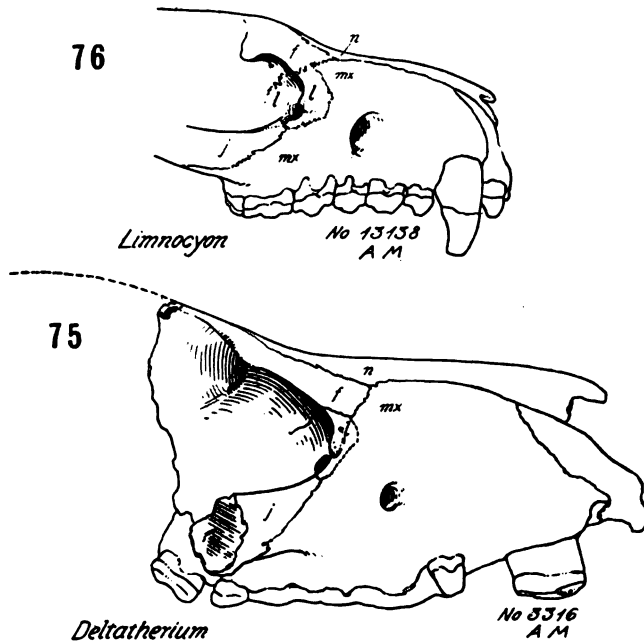
After a long hiatus in our record of the lacrymal during the latter half of the Age of Reptiles, the palæontological record for placental mammals begins in the Paleocene of Europe and North America, by which time most if not all of the placental orders had become well differentiated from each other.

Creodonta

The less specialized creodonts have always been recognized as being very primitive placental mammals, in the construction of the dentition, of the skull, and of the skeleton.

The lacrymal region of various Middle and later Eocene creodonts has been described by Dr. J. L. Wortman (1901, 1902) and by Dr. W. D. Matthew (1907) and is well shown in some exceptionally well preserved skulls in this Museum.

In the very primitive Paleocene *Deltatherium fundaminis* (Fig. 75) the pattern of the lacrymal region is one of the most primitive known among placental mammals. The lacrymal forms part of the distinctly raised anterior rim of the orbit and apparently preserves all its primitive contacts with surrounding elements; it has a moderately developed pars



Figs. 75, 76. Skulls of Creodonts. Class Mammalia, subclass Placentalia, order Carnivora.

75. *Deltatherium fundaminis*. Suborder Procreodi, family Oxyclenidae. Paleocene, Torrejon formation, New Mexico.

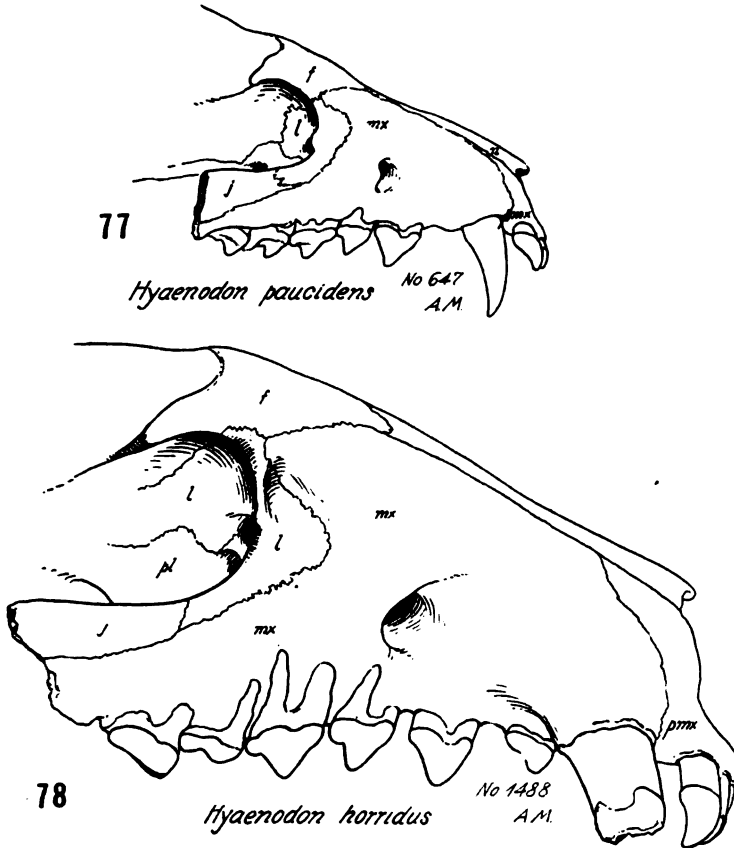
76. *Limnocyon potens*. Suborder Pseudocreodi, family Oxyenidae. Middle Eocene, Lower Bridger, Wyoming.

facialis, a marginal tubercle, with the foramen immediately behind it; there is a good fronto-maxillary contact. The exposed proximal end of the nasals is narrow. The skull was macrosomatic with heavy muzzle, rather small orbits, stout zygomata and unexpanded cranium. The eyes were directed outward and the anterior rims of the orbits were located above m^1 .

In *Limnocyon potens* Matthew (Fig. 76) of the family Oxyenidae essentially identical conditions obtain, except that the pars facialis of the lacrymal is perhaps somewhat larger. *Thinocyon velox* Matthew is a

small member of this family in which the lacrymal region is essentially similar. The maxillary is recessed for the pars facialis and the lacrymal extends well dorsad. The anterior edge of the orbit is above p^4 .

Among the Hyænodontidæ the lacrymal region is perfectly shown in a beautifully preserved skull of *Hyænodon paucidens* Osborn and Wort-



Figs. 77, 78. Skulls of Creodonts (continued).

77. *Hyænodon paucidens*. Suborder Pseudocreodi, family Hyænodontidæ. Middle Oligocene, Oreodon zone, Lower Brule formation. South Dakota.

78. *Hyænodon horridus*. Middle Oligocene, Oreodon zone, Lower Brule formation, South Dakota.

man (Fig. 77); the pars orbitalis is expanded dorsally; the pars facialis is large. The foramen is just medial to the tubercle. The vertical plate of the palatine has the normal carnivore connections with the lacrymal and maxilla. In *Hyænodon horridus* (Fig. 78) the lacrymal region is

similar, save that the pars facialis is somewhat more extended. In *Apterodon*, also, the pars facialis is extended but the orbits are not well rimmed.

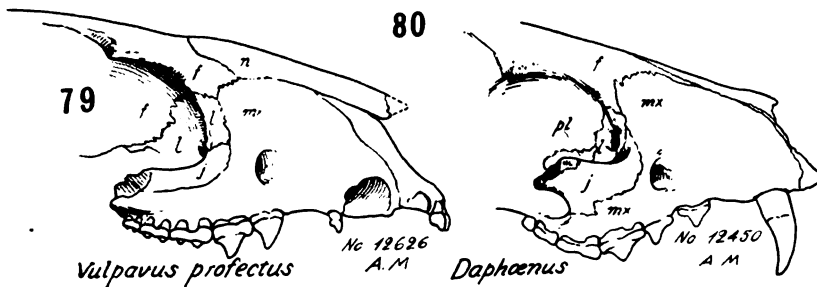
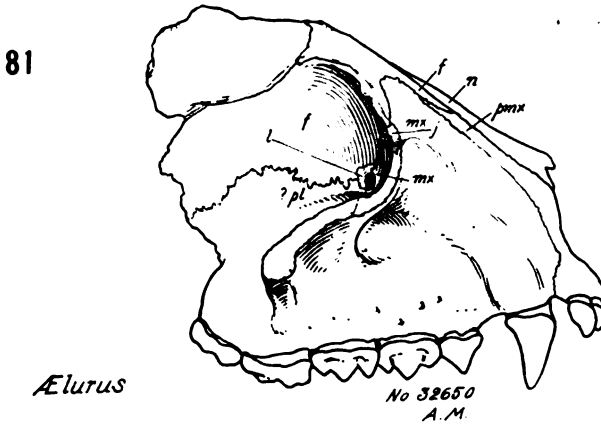
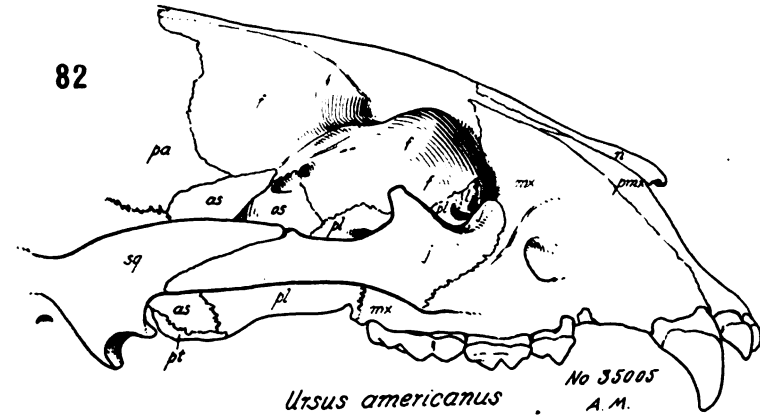
Among the Mesonychidæ the Middle Eocene *Dromocyon* (Wortman, 1901, Pl. iv) shows a very primitive condition of the lacrymal region. Possibly in connection with the backward position of the orbit, the lacrymal is large and bears a well-raised ridge to form the anterior rim of the orbit; the pars facialis is of moderate extent; the foramen is marginal. All the normal contacts with the frontal, maxillary, and jugal are retained. The fronto-maxillary contact is narrow and barely separates the lacrymal from the spreading nasal. The anterior rim of the orbit is quite far back above m^2 . On the whole, this is perhaps the most marsupial-like lacrymal region in all the placentals. In the Upper Eocene *Harpagolestes* the pars facialis is widely extended. Thus the wide extension of the pars facialis, as in the later Mesonychidæ and Hyænodontidæ, is probably a progressive character, while the ancestral creodonts of the Upper Cretaceous may well have had only a moderately developed pars facialis as in *Deltatherium*.

The extension of the pars facialis probably implies in the creodonts, as it does in the artiodactyls, that the inner canthus of the eye was extended forward, together with the orbicularis palpebrarum, preorbicularis dorsalis and p. ventralis muscles. This would cause the eyes to be directed widely outward in contrast with the more forwardly directed eyes of fissipede carnivores.

Fissipedia

The lacrymal of the typical Fissipedia contrasts widely with the above described conditions in the creodonts, since it has little or no pre-orbital extension, the whole bone is never very large, and sometimes (as in *Ælurus*, Fig. 81) is reduced almost to a vestige, which is crowded into the antero-internal corner of the orbit and lacks its primitive dorsal extension. The lower anterior border of the orbit is often formed chiefly by the jugal and the maxillary. This condition is correlated in part with the forwardly directed position of the eyes in modern carnivores. When the true lacrymal tubercle is reduced or absent as in *Lutra* (Fig. 96), a substitute is developed from the maxilla.

At least the more advanced Miacidæ of the Eocene relate as clearly to the Fissipedia in the lacrymal region as they do in the dentition. In *Vulpavus* (Fig. 79) the lacrymal is much smaller than in the contemporary Creodonta Inadaptiva and has only a small pars facialis which does not



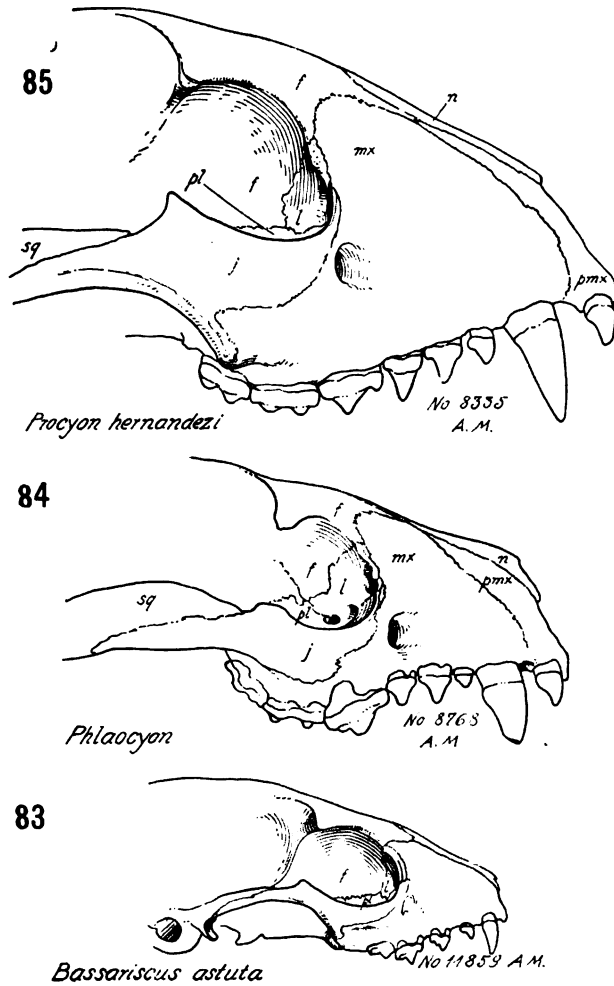
Figs. 79 to 82. Skulls of Carnivora.

79. *Vulpavus profectus*. Suborder Eucreodi, family Miacidæ. Middle Eocene, Orohippus zone, Lower Bridger, Bridger basin, Wyoming.

80. *Daphaenus* sp. Suborder Arctoidea, family Canidæ. Middle Oligocene, Oreodon zone, Brule formation, South Dakota.

81. *Aelurus fulgens*. Suborder Arctoidea, family Procyonidæ.

82. *Ursus americanus*. Suborder Arctoidea, family Ursidæ.



Figs. 83 to 85. Skulls of Procyonidæ. Subclass Placentalia, order Carnivora, suborder Arctoidea.

83. *Bassariscus astuta*.

84. *Phlaocyon leucosteus*. Lower Miocene, Promerycochærus zone, Martin Cañon beds, Colorado.

85. *Procyon hernandezi*.

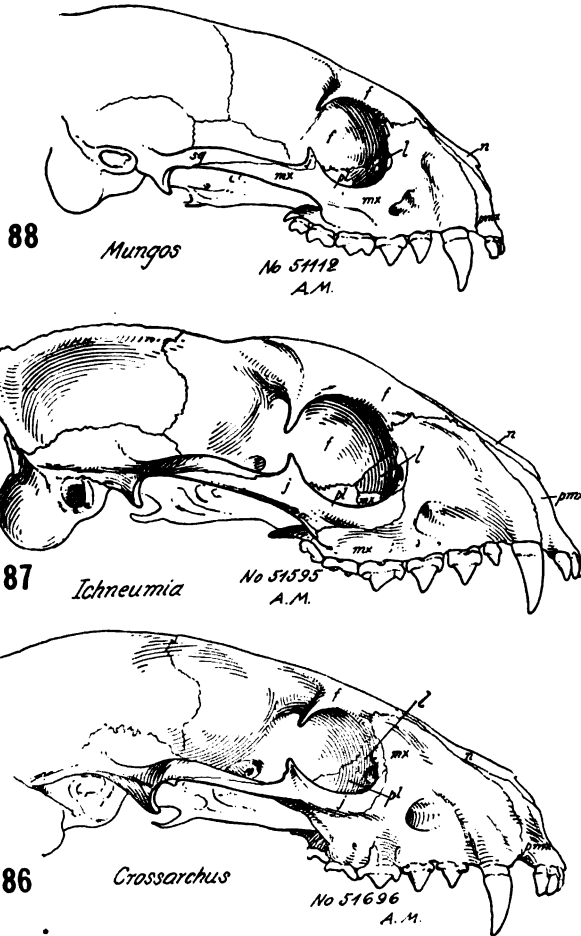
extend beyond the anterior limit of the jugal. The foramen is just behind the low anterior rim of the orbit. The anterior rim of the orbit lies above the fourth upper premolar in *Vulpavus*, as it does also in the creodonts, *Thinocyon*, *Limnocyon*, *Apterodon*, and *Hyænodon*. Hence we cannot ascribe the contrasting condition of the lacrymal in *Vulpavus* and these creodonts to any assumed differences in the position of the orbits with reference to the upper jaw.

Viverravus minutus Matthew is a very small insectivore-like miacid with a long cylindrical skull, very slender zygomata and no orbital ridges. It shows how typical carnivores may give rise to insectivore-like types. The lacrymal region seems to be normal.

In *Cynodictis* of the Canidæ the pars facialis is greatly reduced and the same is true of many other Tertiary and modern fissipeds. In this and other primitive Canidæ, e. g. *Daphænus* (Fig. 80), the lacrymal has a dorsal process which forms part of the orbital rim, and similar conditions are retained in the very primitive genus *Bassariscus* (Fig. 83) of the Procyonidæ. In *Phlaocyon* (Fig. 84), *Procyon* (Fig. 85), and *Nasua* the small orbital rim of the lacrymal bears a small bead-like tubercle. In *Cercoleptes* the lacrymal is very small and in *Ælurus* (Fig. 81) it is vestigial. The last two genera also show similar relations of the jugal and maxilla in this region. In *Æluropus*, according to Lankester's plates (1901), the lacrymal, if present at all, must be very small and confined to the inner wall of the orbit, as it is in *Ælurus* and *Ursus*.

In the Ursidæ (cf. Fig. 82) the lacrymal is much reduced, sometimes almost vestigial, and has usually been withdrawn entirely from the anterior rim of the orbit to the medial surface of the large lacrymal duct. It is thus more or less widely separated from the jugal by the maxilla, which has usurped the place of the lacrymal, and often bears a tubercle for the tarsal ligament. The lacrymal in this family, like other vestigial structures, is more or less variable in form and position. For example, on the left side of a skull of *Ursus malayanus* (Amer. Mus. No. 296) the lacrymal sends a thin flange forward and outward to the anterior margin of the orbit; on the right side it lacks this flange and is restricted to the medial wall of the lacrymal tunnel. In one specimen of *Ursus horribilis alexandræ* (Amer. Mus. No. 16702) the lacrymal on the left side appears to have a considerable dorsal extension on the inner wall of the orbit. In the skull of a Polar Bear (*Ursus maritimus*, Amer. Mus. No. 19259) the very small lacrymal is excluded from contact with the palatine by a process of the maxilla, and the same is true in *U. malayanus* (Amer. Mus. No. 296). But at least in certain skulls of *Ursus americanus* (Fig. 82) and *Ursus horribilis* the lacrymal is in contact with the palatine.

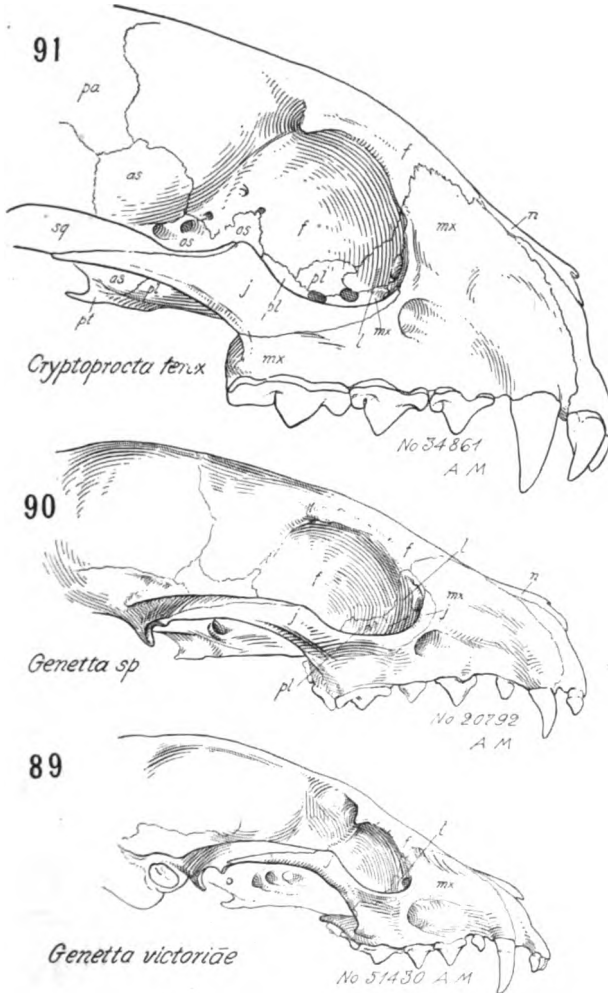
Constant features of the Ursidæ are the great forward extension of the palatine on the inner wall of the orbit and the presence of a large foramen or tunnel, usually between the palatine and the lacrymal and



Figs. 86 to 88. Skulls of Viverridæ. Subclass Placentalia, order Carnivora, sub-order Æluroidea, family Viverridæ.

immediately behind the lacrymal foramen. This tunnel, like the last-named structure, leads downward into the nasal chamber and at first looks like a second lacrymal foramen, but it is sometimes subdivided (e. g., *U. maritimus*, Amer. Mus. No. 19259) into several openings, which

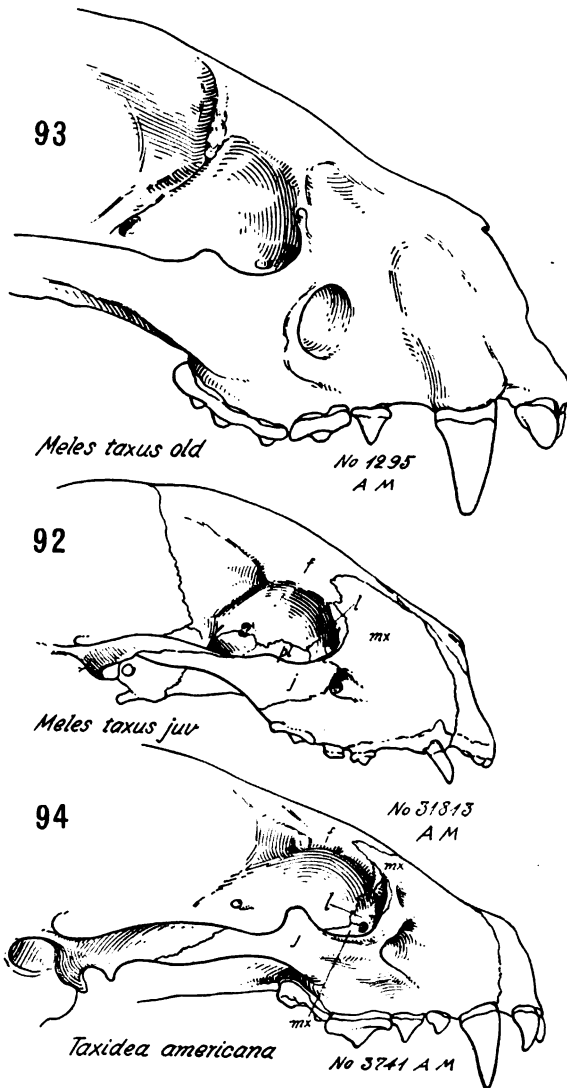
are possibly for branches of the internal maxillary artery. A very similar opening is present in the same location in the *Canidæ*. Indeed, the whole inner wall of the orbit in the *Ursidæ* presents several points of



Figs. 89 to 91. Skulls of Viverridæ (continued).

resemblance with the conditions observed in *Canis*, *Mustela*, and *Ælurus*.

In the more primitive genera of the Viverridæ (*Crossarchus*, Fig. 86, *Ichneumia*, Fig. 87), the lacrymal itself bears the tubercle and has a small pars facialis. Remnants of this condition are found in other



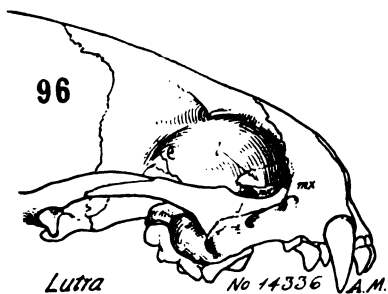
Figs. 92 to 94. Skulls of Mustelidæ. Subclass Placentalia, order Carnivora, sub-order Arctoidea, family Mustelidæ.

98

*Lutra*

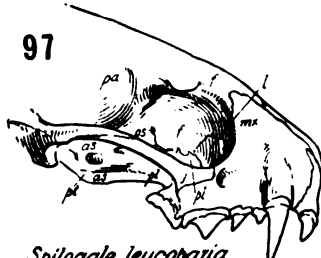
No 41353 A.M.

96

*Lutra*

No 14336 A.M.

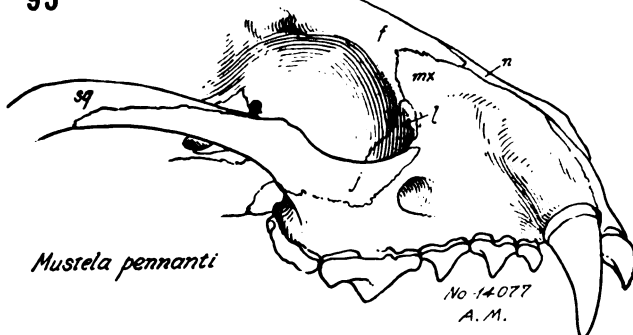
97

*Spilogale leucoparia*

No 14818

A.M.

95

*Musrela pennanti*

No 14077

A.M.

Figs. 95 to 98. Skulls of Mustelidæ (continued).

Viverridæ (Fig. 90) and Felidæ and to some extent in the Hyænidæ. In *Genetta victoriæ* (Fig. 89) the lacrymal is much reduced and the maxilla usurps its place on the anterior rim of the orbit. *Mongos* (Fig. 88) is remarkable for the vestigial condition of the jugal, which is functionally replaced by the maxilla. In *Cryptoprocta* (Fig. 91) the tubercle is borne by the maxilla.

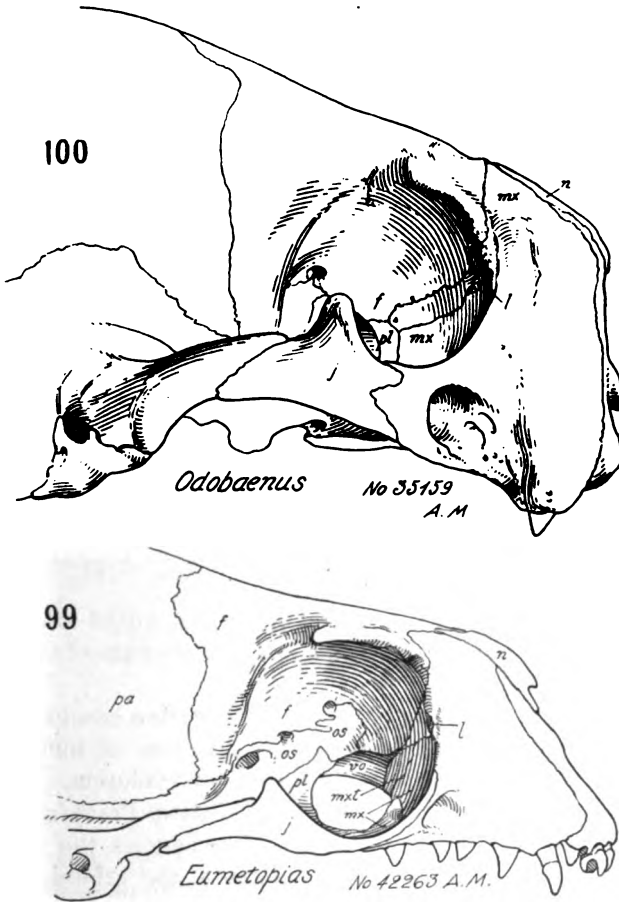
In the Mustelidæ, *Mustela* (Fig. 95) and the young *Meles* (Fig. 92) have a fair-sized lacrymal bearing a small tubercle on the antorbital rim. In *Taxidea* (Fig. 94), which is a very different genus from *Meles*, the antorbital rim is chiefly made from the maxillary; the same is true of most of the other Mustelidæ in which the facial part of the lacrymal is very small. In *Lutra* (Fig. 96) and *Latax* (Fig. 98) the antorbital rim of the maxillary is sharply ridged for the orbit and the lacrymal is extended anteroposteriorly on the inner wall of the orbit. In these characters, as in many others, the otters relate to the skunks (cf. Fig. 97).

Thus in most modern Fissipedia the lacrymal tends to be reduced and withdrawn from the anterior rim of the orbit to its inner surface, while the maxillary usurps the place of the lacrymal and forms the tubercle. The orbital plate of the palatine is enlarged, often crowding the lacrymal forward to the corner of the orbit.

Pinnipedia

The most primitive known condition of the lacrymal in this group is found in the Otariidæ (cf. Fig. 99); here the lacrymal is a thin sliver of bone, extended more or less transversely on the prominent anterior wall of the orbit and ending laterally in a very projecting tubercle, the front face of which is composed largely of a spur from the maxilla. The latter forms the anterior rim of the orbit below the tubercle and widely separates the lacrymal from the jugal. Possibly the separation of these two elements is due to the great enlargement of the orbit which has dragged the jugal outward and backward. The lacrymal is also widely separated from the palatine, the orbital plate of which is membranous, leaving, in the dried skull, a large vacuity in the side of the brain-case, and exposing the vomer and the maxillo-turbinals. The vacuity in question extends forward between the frontal and the maxilla to the posterior border of the lacrymal. The latter co-operates with the maxilla and the frontal in covering the posterior extension of the greatly enlarged maxillo-turbinals, which appear to have obliterated the maxillary antrum, and to have encroached upon the ethmo-turbinals, which in this group are greatly reduced. The lacrymal itself is imperforate, and apparently the lacrymal duct is absent.

In a very young Atlantic walrus (*Odobænus rosmarus*, Amer. Mus. No. 35159, Fig. 100) an apparent vestige of the lacrymal is represented by an extremely thin sliver of bone covering the maxillo-turbinals on



Figs. 99 to 100. Skulls of Pinnipedia. Subclass Placentalia, order Carnivora, suborder Pinnipedia.

99. *Eumetopias stelleri*. Family Otariidæ.

100. *Odobænus rosmarus*. Family Odobænidæ.

the inner wall of the orbit between the frontal and the maxilla. The very large projecting tubercle is borne by the maxilla. The whole conformation of the lacrymal and orbital region is fundamentally the same

as in the Otariidæ, and testifies to the relatively close relationship of these two families, which is already established by other evidence.¹

In all the Phocidæ the orbits are very large and the lacrymal is apparently absent, at least as a bony element; but its former site may be indicated by a vacuity on the inner wall of the orbit between the frontal and the maxilla. In the dried skull this vacuity partly exposes the maxillo-turbinals. The whole appearance of this region recalls the above-described conditions in the walrus, in which the orbital plate of the maxillo-turbinal is covered by the vestigial lacrymal. The tubercle, when developed (*Erignathus barbatus*, *Phoca grænländica*, *Cystophora cristata*, etc.), is borned by the maxilla. The lacrymal duct is absent.

As a whole, the orbital region of the Phocidæ suggests that this family is a specialized offshoot of the walrus-furseal stem, a conclusion which is strongly reinforced by the evidence of other parts of the skull, such as the auditory and olfactory regions.

The reduction and final disappearance of the lacrymal in this sub-order are doubtless more or less correlated with the great enlargement of the maxillo-turbinals, and the loss of the lacrymal duct.

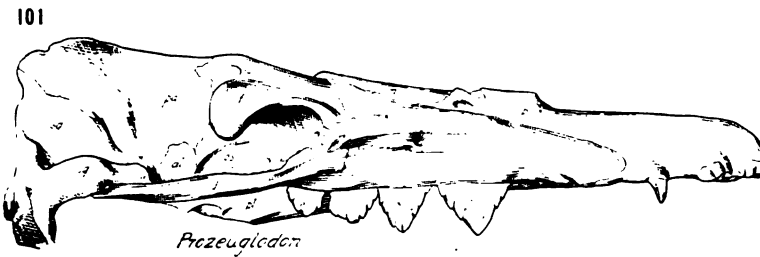
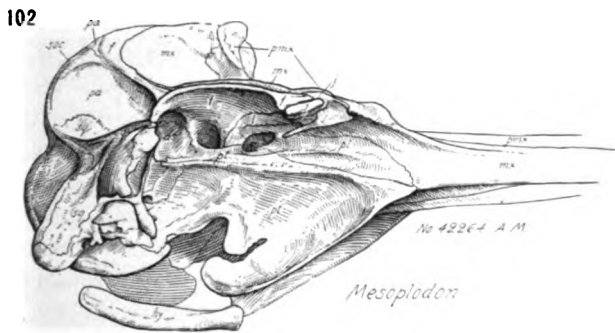
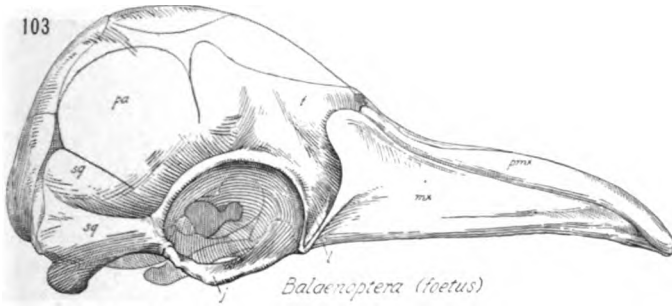
The evidence suggests that the Pinnipedia sprang from some group of Carnivora in which the facial part of the lacrymal had already been lost, but the lacrymal still formed part of the anterior rim of the orbit and bore a normal tubercle as it does in the more primitive Fissipedia.

Cetacea

The morphology of the lacrymal of Cetacea will be more intelligible if considered in connection with the general evolution of the facial part of the skull in this order.

All recent work strengthens the conservative conclusion that the extinct Archæoceti were real cetaceans, and not, as some have held, pseudo-cetaceans, the product of convergent evolution. In the most primitive stage of the Archæoceti, *Protocetus atavus* Fraas from the Lower Tertiary of Egypt, the skull already foreshadows the more typical archæocete type. The rostrum is elongate, the orbital plate of the frontals is widened, and the anterior nares are beginning their shift dorsad. Even *Zeuglodon* itself, though belonging to an extinct side line, shows the following significant skull characters. The skull, as seen from above, is roughly triangular, with widely projecting zygomatic processes of the squamosals and slender jugals. The rostrum is moderately elongate, with the anterior nares dorsal in position, but still well in front of the eyes. The eyes are concealed from above by a broad, rather flat expanse of the frontals. The frontal processes of the maxillæ

¹Amer. Journ. Sci., XXI, pp. 444-450.



Figs. 101 to 103. Skulls of Cetacea. Subclass Placentalia, order Cetacea.

101. *Prozeuglodon atrox*. Suborder Archæoceti, family Zeuglodontidæ. Upper Eocene, Birket-el-Qurun beds, Fayûm, Egypt. After Andrews.
 102. *Mesoplodon grayi*. Suborder Odontoceti, family Ziphiidæ.
 103. *Balaenoptera borealis*. Suborder Mysticoceti, family Balænopteridæ. After Schulte.

are very wide, but do not yet overlap the orbits. The lacrymal of *Prozeuglodon* (Fig. 101) (as figured by Andrews, 1906, Pl. XXI) recalls the type of the inadaptable creodonts, as it has a well-developed pars facialis and retains its normal contacts with the maxilla, jugal, palatine, and frontal. At this stage the lacrymal still forms the anterior rim of the orbit.

In the Upper Oligocene *Patriocetus*, which is regarded by Abel (1914, p. 88) as an ancestral mystacocete, the dentition, as figured in Abel's reconstruction, is of archæocete type, but the wide skull plainly approaches that of the more primitive mystacocetes. The anterior nares are more dorsal, the narial channel between the elongate premaxillæ exposes the vomer in the dorsal view. The orbital plate of the frontal is not far in advance of the stout zygomatic process of the squamosal, and the small orbit is just above the level of the long sloping ascending ramus of the mandible. The maxillo-frontal contact is wide and apparently conceals the lacrymal in the side view of the skull.

The skull of the Miocene *Cetotherium* (Abel, 1914, p. 91), a primitive balænopterid, may readily be derived from the *Patriocetus* type by the great enlargement of the mouth and jaws, the loss of the teeth, the down-growth of baleen plates from the palate, and the subsequent arching of the rostrum. The dorsad shifting of the nares is now virtually complete, as well as the backward and upward growth of the maxillæ and the backward shifting of the orbits, the postorbital process of the frontal being in contact with the massive zygomatic process of the squamosal. In the foetal *Balæna japonica*, as figured by Eschricht (Weber, 1904, p. 555), and in the foetal *Balænoptera borealis* (Fig. 103), as figured by Schulte (1916, Pls. LIV, LV), the imperforate lacrymal is reduced to a long sliver of bone, which is pressed between the frontal process of the maxilla and the orbital apophysis of the frontal. In spite of the downward and outward prolongation of the orbit, the lacrymal retains its primitive contacts at least with the frontal, the maxilla, and the slender jugal.

The relations of the lacrymal with the jugal in the odontocetes have been used as a diagnostic character by Flower (1866), who concluded that among existing cetaceans the lacrymal is a free element only in the Ziphiinæ, while in the Physeterinæ, as well as in the Delphinidæ and the Platanistidæ, it is usually fused with the jugal. Abel (1902, p. 150), however, noted that in *Beluga* of the Delphinidæ, as well as in the Miocene *Eurhinodelphis*, the lacrymal is sometimes distinct from the jugal in young skulls.

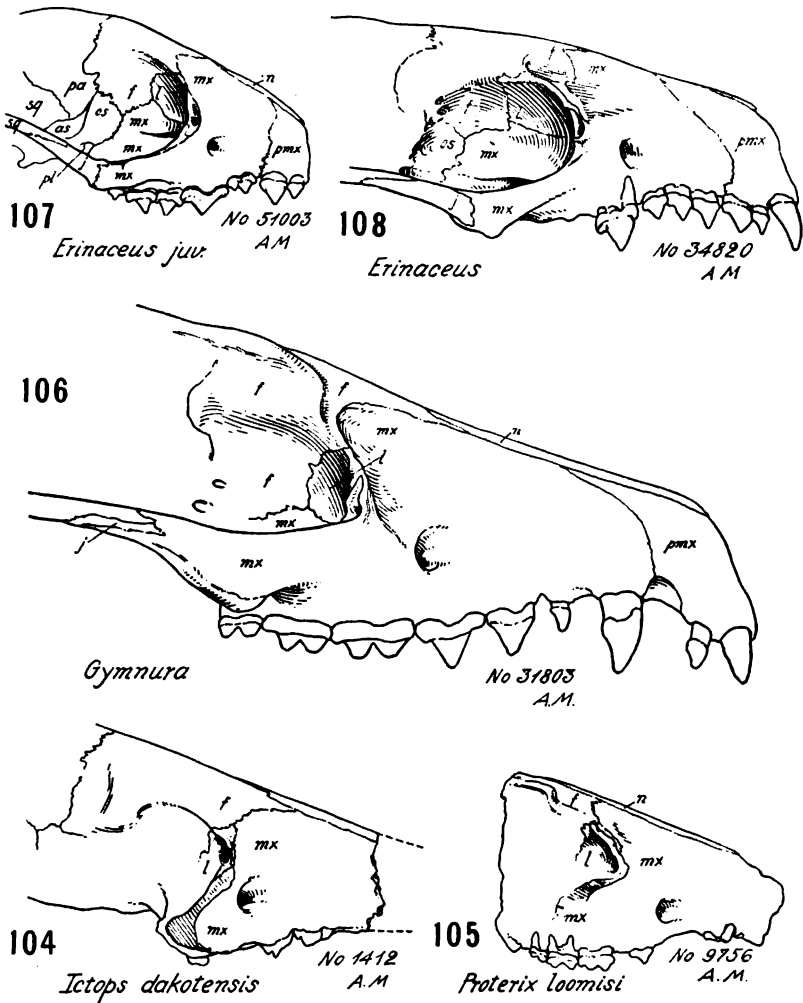
The general relations of the lacrymal in the odontocetes seem to have been foreshadowed in the extinct Squalodontidæ, in which the supraorbital region is fundamentally like that of the Ziphiinæ. In dentition and skull characters the Squalodontidæ tend to connect the physeterid odontocetes with the archæocetes (Abel, 1914, pp. 86, 92-94).

In existing odontocetes the most complete and primitive condition of the lacrymal is seen in the Ziphiinæ. In a young *Mesoplodon grayi* (Amer. Mus. No. 42264; Fig. 102) the lacrymal is a flattened bone lying beneath the expanded orbital plates of the frontal and maxillæ, and forming part of the roof of the orbit; laterally it forms the anterior part of the rim of the orbit and is in contact with the anterior end of the jugal, with the maxilla, the frontal, the palatine, and the pterygoid.

In *Ziphius cavirostris*, according to Kernan (1918, p. 374), the lacrymal is a rather massive disc-like bone on the roof of the orbit, in contact with the maxilla, the jugal, the frontal, the palatine, and the pterygoid. It is pierced by a canal and a fissure which, Dr. Kernan suggests, probably represent the lacrymal canal of other mammals.

In *Kogia breviceps*, of the family Physeteridæ, Schulte (1917, p. 390) states that "it has been open to question whether the jugal might not have disappeared and the element so named be really interpreted as lachrymal, or perhaps as lachrymal and malar, with the zygomatic process of the latter reduced to a ligament. In a dissection of a new-born *Kogia*, a perfectly definite ligamentous arch was present connecting the tip of the malar to the zygomatic process of the squamosal. Very fortunately the skull of the calf on the left side has a separate malar and lacrymal, the latter nasal in position and interposed between the maxilla and the frontal. It is evident, therefore, that the usual elements are present but that the zygomatic process of the malar has been reduced so that it no longer appears as bone." The lacrymal of this animal is overlaid by the frontal and by the maxilla; it also articulates with the malar.

If it be considered remarkable that the lacrymal should persist at all in these excessively specialized skulls, it may be suggested that this element has been sheltered, as it were, by the overlying orbital plates of the frontal and of the maxilla, so that even in *Kogia*, when the rostrum became greatly shortened and the maxillæ and premaxillæ grew even further upward to support the enormous nasal chamber, the lacrymals retained their sheltered place beneath these elements on the roof of the orbits, although in this genus they have been crowded away from the supraorbital margin by the secondary enlargement of the jugal.



Figs. 104 to 108. Skulls of lipotyphlous Insectivores. Subclass Placentalia, order Insectivora, suborder Erinaceoidei.

104. *Ictops dakotensis*. Family Leptictidae. Middle Oligocene, Oreodon zone, Lower Brule formation, South Dakota.
105. *Proterix loomisii*. Family Erinaceidae. Middle Oligocene, Oreodon zone, Lower Brule formation, South Dakota.
106. *Gymnura rafflesi*. Family Erinaceidae.
107. *Erinaceus (Atelerix) langi*. Family Erinaceidae.
108. *Erinaceus europæus*. Family Erinaceidae.

Insectivora (Lipotyphla)

The true Insectivora (Lipotyphla) may be conceived either as the rather highly modified descendants of some of the Mesozoic Trituberculata or as merely dwarfed and degenerate Pro-carnivora. Possibly there may be some truth in both views. At any rate, the Zalambdodonta, which are perhaps the most archaic members of the series, are evidently degenerate and retrogressive in the lacrymal region as will be shown below. Very probably the most primitive lacrymal region is preserved in the Eocene and Oligocene Leptictidæ (Figs. 104, 105). The skull, as is usual in primitive mammals, is macrosmatic, with expanded ethmoid region; the lacrymal forms parts of the anterior rim of the orbit, with a marginal tubercle and the foramen just medial to it. The lacrymal has a somewhat dorsal position, perhaps as a result of the expansion of the infraorbital canal for the ramus maxillaris of the trigeminal nerve, which is commonly enlarged in animals with a highly sensitive snout. In *Proterix loomisi* Matthew (Fig. 105) the lacrymal begins to resemble that of *Erinaceus* (Figs. 107, 108) as described below. In the existing *Gymnura* (Fig. 106) the ridge on the outer border of the lacrymal that forms the anterior rim of the orbit is sharply defined and separates the eye and its muscles from the area for the naso-labialis and scutularis muscle, which is well defined in front of the eye¹. The marginal foramen opens partly outward. The jugal is a small element in the middle of the zygomatic arch and is widely separated from the lacrymal.

In *Erinaceus* (Figs. 107, 108) that part of the maxilla which forms the bridge over the infraorbital canal becomes further enlarged at the expense of the lacrymal and the jugal, which are widely separated by it from each other. The lower part of the lacrymal fuses with this bridge but the suture is evident in a very young skull of *Erinaceus*. The foramen still perforates the lacrymal, but now opens laterally rather than posteriorly. The dorsally expanded orbital plate of the lacrymal covers the greatly enlarged dorsal ethmo-turbinate. The lacrymal is excluded from contact with the palatine by the maxillary. The fronto-maxillary contact is wide and the exposed proximal ends of the nasals are narrow.

The lacrymal region in *Palæoryctes puercensis* Matthew (1913), the Paleocene representative of the zalambdodont Insectivora, is not known.

In *Nesophontes*, a primitive zalambdodont of Porto Rico and Cuba recently described by H. E. Anthony (1918), the skull as a whole much resembles that of a young *Solenodon*, except for the more primitive

¹See the dissections in Boss and Paulli (1908, Pl. II).

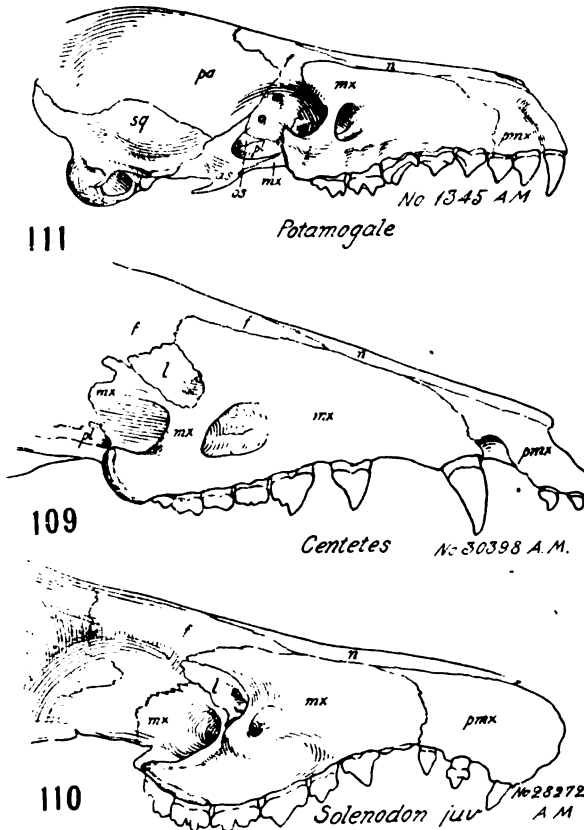
character of the dentition and the greater length of the basicranial region. As in *Solenodon*, the lacrymal is probably fused in the adult with the surrounding elements. The well-developed lacrymal foramen is marginal, immediately above and behind the large infraorbital foramen. In the modern *Centetes* (Fig. 109) the lacrymal region is rather specialized. The animal is highly macrosomatic and the region covering the ethmoturbinals is expanded and cylindrical; the anterior processes of the frontals extend far forward over the maxillæ and widely separate the narrow coössified nasals from the lacrymal. The latter has been displaced dorsad through the marked enlargement of the infraorbital canal of the maxillary, which, as in *Gymnura*, appears to indicate a great development of the superior maxillary nerve. The maxillary has also encroached upon the orbital plate of the palatine which is reduced in size. The lacrymal itself has contact laterally only with the maxillary bridge over the infraorbital canal, which to some extent functionally replaces the absent jugal. The orbital surface of the lacrymal is flatly expanded without spine or crest; the foramen is located at the anterior border of the lacrymal and opens laterally. There is technically little or no pars facialis, since the lacrymal is not extended in front of the orbit. The eyes are very small and face outward.

In *Microgale* and *Echinops* the lacrymal region appears essentially the same as in *Centetes*. In *Hemicentetes* the lacrymal is covered by the ascending process of the maxilla.

In *Solenodon* (Fig. 110) the small, dorsally displaced lacrymal is widely extended on the inner wall of the orbit; the large foramen pierces its anterior end. The region as a whole is essentially like that of *Centetes*. Accordingly, it may be said that the lacrymal region of the Centetidae is especially characterized as follows: (1) by the encroachment of the maxillary, which crowds the lacrymal dorsad above the enlarged infraorbital canal; (2) by the forward growth of the frontals, covering the proximal end of the nasals and widely separating them from the lacrymal; (3) by the reduction of the eyes, causing the loss of an orbital rim and of the lacrymal tubercle; (4) by the expansion and cylindrical form of the ethmoid region, causing the anteroposterior flattening of the lacrymal against the inner wall of the orbit.

In *Potamogale* (Fig. 111) the infraorbital bridge of the maxillary is further enlarged and extends still higher up on the side of the face. The lacrymal foramen is vestigial and the lacrymal itself is vestigial or absent. The orbital plate of the palatine, however, is not reduced.

In *Talpa*, according to W. K. Parker's figures (1885) of a young skull, the small lacrymal is separated from the nasals by the wide fronto-maxillary contact. The lacrymal is closely appressed to the side



Figs. 109 to 111. Skulls of Zalambdodont Insectivores. Subclass Placentalia, order Insectivora, suborder Centetoidea (Zalambdodonta).

109. *Centetes caudatus*. Family Centetidae.

110. *Solenodon paradoxus*. Family Solenodontidae.

111. *Potamogale velox*. Family Potamogalidae.

of the face and the lacrymal foramen has shifted forward and lies between the maxilla and the anterior process (pars facialis) of the lacrymal. In an embryo *Sorex* the small lacrymal lies behind the emarginate ascending process of the maxilla (*op. cit.*, Pl. xxxi).

In *Pantolestes natans* Matthew (1907, 1918), which is referred by Dr. Matthew to the Insectivora, the lacrymal itself is not preserved but

the infraorbital is expanded as in many insectivores and the lacrymal was probably small and somewhat displaced dorsad. There is a wide fronto-maxillary contact and the exposed proximal end of the nasals is tapering.

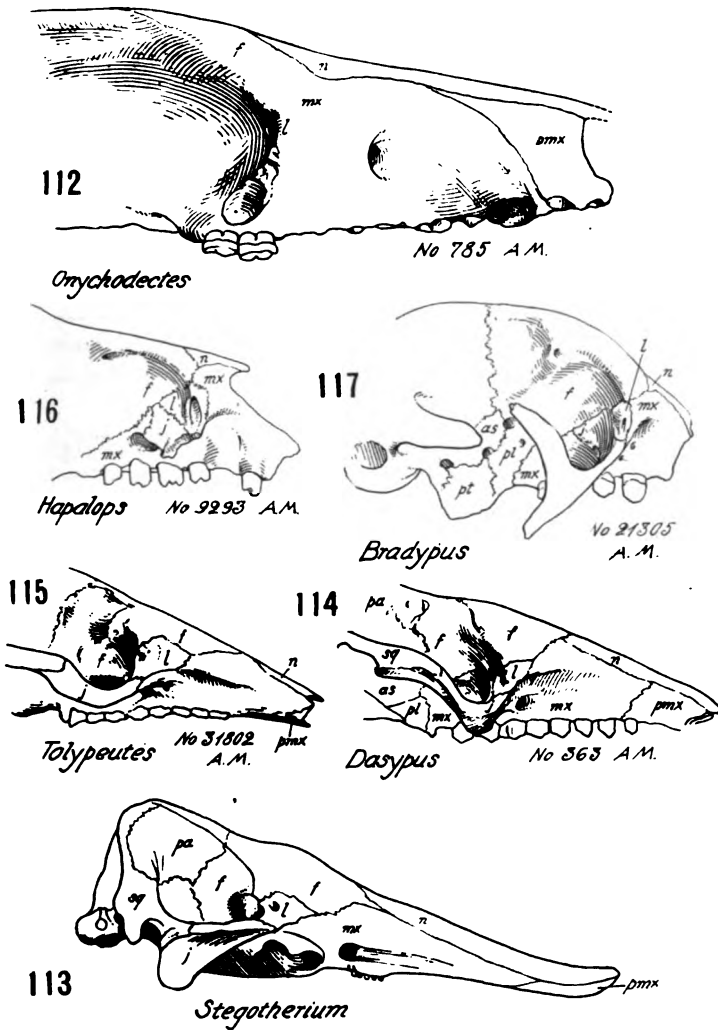
Thus the lacrymal region of the true Insectivora exhibits two principal types. First, and most primitive, is that of the Leptictidæ, in which the lacrymal takes part in the anterior rim of the orbit; it bears a distinct tubercle and has a small pars facialis above the lacrymal foramen, which is marginal in position; the erinaceid type of lacrymal is derived directly from this by the reduction of the pars facialis. The second type is exhibited in the zalambdodonts, including *Nesophontes*, in which the lacrymal is appressed to the inner wall of the orbit and is extended dorso-caudally above the enlarged infraorbital canal; the large lacrymal foramen is marginal; there is no tubercle and the maxilla is deeply notched for the reception of the lacrymal. Similar but more reduced types of lacrymal occur in *Talpa* and *Sorex*. In *Potamogale* (Fig. 111) the lacrymal is wanting.

Tæniodonta (Ganodonta)

Onychodectes (Fig. 112), a very primitive member of the Paleocene Conoryctidæ, has a long, more or less tubular macrosomatic type of skull which recalls that of primitive Insectivora. There are no distinct post-orbital processes on the frontals; the lacrymal was on the anterior rim of the orbit. The sutures are not clear; a double tubercle on the upper part of the anterior rim of the orbit marks the point of attachment of the palpebral ligament and was apparently borne by the lacrymal. The lacrymal foramen was below this ridge and within the margin of the orbit, as in all other primitive placental mammals. On the whole, the lacrymal region recalls that of the Leptictidæ.

In the specialized genus *Psittacotherium* the position and limits of the lacrymal are not clear. The facial portion of the skull has been described by Dr. Wortman (1897, pp. 72, 74) as follows:

In the skull (Fig. 4) the facial portion is seen to be short and deep, the sagittal crest short and inconspicuous, and there is but a faint indication of postorbital processes upon the frontals. The anterior root of the zygoma is situated well forward; it has a considerable vertical depth and projects outwards, downwards, and backwards. In front of and below the zygomatic root is a shallow fossa, at the upper extremity of which is the anterior opening of the infraorbital canal, which is double. Leidy describes two foramina in this situation in *Megalonyx* (Fig. 5), and it is not an infrequent occurrence for this foramen to be double in the modern sloth. In *Psittacotherium* the main canal is below and the smaller one above. Both, however, are placed unusually high on the face. No evidence of a distinct lacrymal is to be seen.



Figs. 112 to 117. Skulls of Edentates. Subclass Placentalia, order Edentata.

112. *Onychodectes tisonensis*. Suborder Teniodonta, family Conoryctidae. Paleocene, Polymastodon zone, Puerco formation, New Mexico.
113. *Stegotherium tessellatum*. Family Dasypodidae. Middle (?) Miocene, Santa Cruz formation, Patagonia. After Scott.
114. *Dasypus aztecinctus*. Suborder Xenarthra, family Dasypodidae.
115. *Tolypeutes conurus*. Suborder Xenarthra, family Dasypodidae.
116. *Hapalops ruefemeyeri* (?). Suborder Xenarthra, family Megalonychidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.
117. *Bradypus* sp. Suborder Xenarthra, family Bradypodidae.

It may also be noted that the frontals send forward anterior processes for articulation with the maxillæ.

If the tæniodonts are primitive edentates, as held by Dr. Wortman, they show that here, as in other orders, the primitive forms have a well-defined anterior orbital rim, formed in part by the lacrymal, the lacrymal foramen being behind this rim and below the lacrymal tubercle.

Edentata (Xenarthra)

The lacrymal region is not well shown either in the Paleocene *Palæanodon* Matthew (1918) or in the Middle Eocene *Metachiromys*. The skull of the latter, however, approaches the armadillo type, especially in the wide expansion of the frontals anteriorly. The whole region is highly macrosomatic, the ethmo-turbinals being greatly expanded. There is a wide contact between the frontals and the maxilla, due to the marked forward growth of the frontals.

Prodasyptus of the Santa Cruz formation, as described by Professor Scott (1906), has a fairly primitive lacrymal with a projecting antorbital rim and a small pars facialis. In *Dasyptus* (Fig. 114) the lacrymal is on the face and chiefly in front of the orbit; the foramen is external in position. The orbital part of the lacrymal is limited.

In *Stegotherium* (Fig. 113), a long-faced relative of *Tatusia*, figured by Professor Scott, the lacrymal has an extended pars facialis with a lateral foramen and groove.

In the young *Tatusia hybrida*, as figured by Parker (1885, Pl. VI), the large lacrymal forms the prominent anterior rim of the orbit while the jugal is reduced. The pars facialis is large. The foramen is immediately in front of the orbital rim.

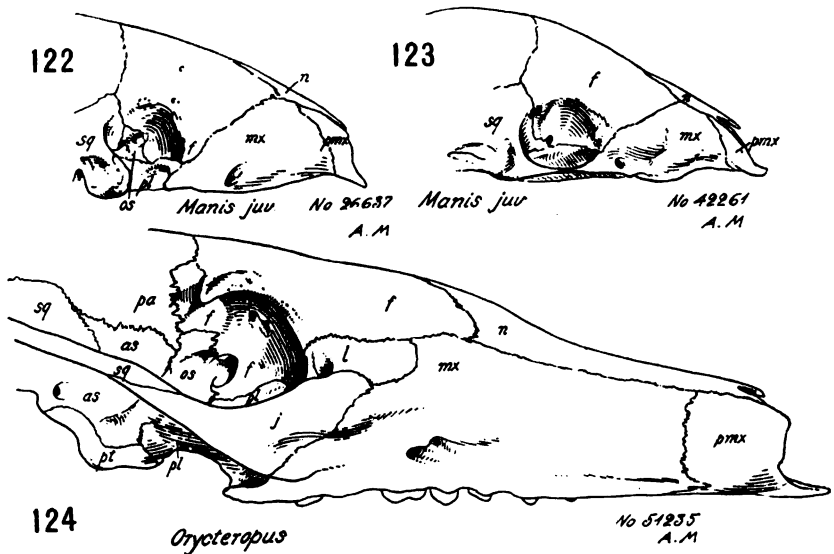
Thus in the armadillos the orbital part of the lacrymal is reduced, the facial part more or less extended, and the foramen is external. The lacrymal is widely separated from the palatine by the maxilla.

In the Santa Cruz glyptodonts the lacrymal has been displaced dorsad through the enlargement of the zygoma.

Among the Santa Cruz ground-sloths, *Hapalops* (Fig. 116) has a relatively primitive lacrymal with a moderate-sized pars facialis; the foramen is immediately in front of the orbit. The pars orbitalis is separated from the maxilla by an orbital extension of the jugal. Similar conditions persist in the modern sloths (Fig. 117). Among the Mylodontidæ, *Scelidotherium* (Fig. 118) exhibits a relatively primitive condition of the lacrymal. In *Myrmecophaga* (Fig. 119) the great extension of the facial part of the lacrymal is probably connected with the still

greater forward growth of the frontal. Two foramina are present, presumably for the upper and lower palpebral branches of the lacrymal gland. In *Tamandua* (Fig. 120), with its shorter snout, the pars facialis is much less extended. In *Cyclopes* (Fig. 121), in which the snout is secondarily shortened, the lacrymal is crowded between the outwardly spreading maxilla and the frontal, the pars facialis being greatly reduced and the fronto-maxillary contact reduced or absent. In the ant-eaters the lacrymal is in contact with the palatine, but in the sloths it is widely separated from it by the maxilla and the jugal.

Accordingly, we find that the lacrymals of xenarthrous edentates



Figs. 122 to 124. Skulls of *Manis* (subclass Placentalia, order Edentata, suborder Pholidota) and *Orycteropus* (subclass Placentalia, order Tubulidentata).

122. *Manis* sp. Family Manidae. Young individual.

123. *Manis* sp. Young individual showing secondary zygomatic arch formed by union of processes from the squamosal and maxilla.

124. *Orycteropus* sp. Family Orycteropodidae.

differ widely among themselves; in the armadillos the lacrymal is mostly external to the orbit and widely separated by the maxilla from the palatine. In the sloths, on the other hand, the orbital portion is well defined, but separated from the maxilla by the orbital process of the jugal. In the ant-eaters, with the reduction of the jugal the lacrymal gains a presumably secondary contact with the palatine.

Pholidota

In two very young *Manis* skulls (Amer. Mus. Nos. 26637, 42261, Figs. 122, 123) with sutures all open, there is no trace of a distinct lacrymal, its position being usurped by the vertical plate of the palatine and the descending wall of the frontal. There is a very wide fronto-maxillary contact. A conspicuous foramen at the anterior corner of the orbit, between the frontal and the palatine, at first looks like the lacrymal foramen, but is more probably the spheno-palatine foramen; although Weber (1904, p. 422), after stating that a lacrymal is seldom retained but generally is fused with the maxilla, says that it is always imperforate and that the lacrymal foramen lies between the frontal and the palatine. Possibly the disappearance of the lacrymal in *Manis* may be correlated to some extent with a caudad displacement of the orbits, which have become confluent with the temporal fossa, the preorbital part of the frontal extending downward over the territory of the lacrymal and usurping both its function and position.

Recently Dr. Matthew has shown (1918) that the Pholidota may very well be derived from primitive Xenarthra. In *Manis* the confluence of the orbit with the temporal fossa and the loss of the jugal are conditions that are more or less foreshadowed in *Cyclopes*, while the wide fronto-maxillary contact is seen in *Stegotherium*.

Tubulidentata

In *Orycteropus* (Fig. 124) the lacrymal region recalls the type found in *Myrmecobius*, *Tupaia*, Eocene Artiodactyla, and other genera in which the ethmoid region is widely expanded, the orbit is placed far backward and the lacrymal projects laterally, forming an anterior rim of the orbit and extending well forward on the face. The foramen is external, the pars orbitalis is considerably reduced by the encroachment of the palatine and frontal. The fronto-maxillary contact is well developed. Much of this condition may have resulted from a caudad displacement of the orbits, correlated with a forward growth of the frontal.

The conditions in the lacrymal region of *Orycteropus* could well be derived from those in the Condylarthra to be described below.

Tillodontia

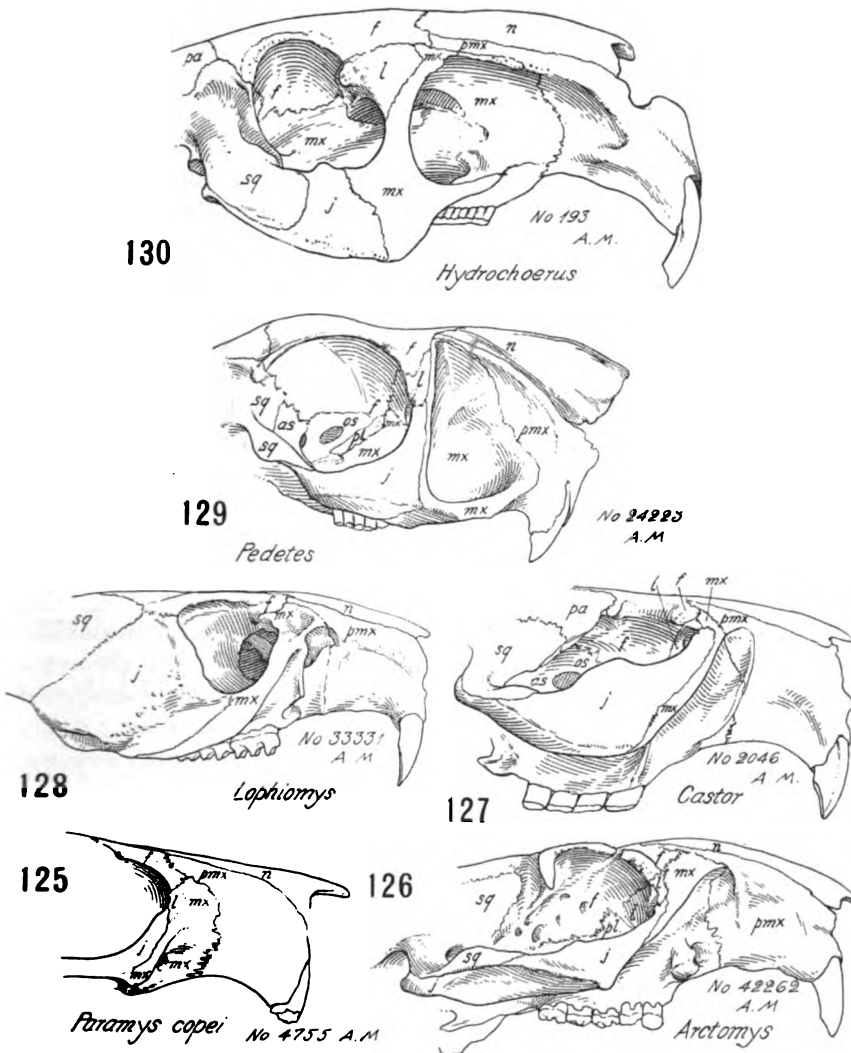
In the Middle Eocene *Tillotherium* the lacrymal region appears to be fairly primitive and creodont-like in spite of the rodent-like modification of the front teeth. The lacrymal forms the anterior border of the orbit; the pars orbitalis is moderately extended dorsally; the pars

facialis is small; the foramen and tubercle are marginal. There is a wide fronto-maxillary contact.

Rodentia

The oldest known rodents, the Ischyromyidæ of the Eocene (cf. Matthew, 1910) already show the chief ordinal characteristics of the skull and dentition. In correlation with the gliriform modification of the incisors (Fig. 125) the premaxillæ are much enlarged and extend up above the maxillæ and lacrymals to gain contact with the frontals; the fronto-maxillary contact and the facial part of the lacrymal are accordingly much restricted; in correlation with the expansion of the masseter the zygomatic arch is typically stout, and the jugal is supported by a more or less well-developed zygomatic process of the maxilla, which bears a tubercle for the anterior end of the masseter lateralis. Post-orbital processes of the frontals are not developed. The modern *Archomys* (Fig. 126) has advanced beyond this primitive rodent condition by the differentiation of a special slip of the masseter lateralis which has grown forward along the anterior preorbital border of the zygomatic arch so as to invade the lateral surface of the maxilla above the infra-orbital canal, even reaching the premaxilla. The lacrymal, however, which was already reduced in *Paramys*, retains its place in the anterior rim of the orbit, in contact with the maxilla, jugal, palatine, and frontal. It is traversed by the lacrymal duct. The main tubercle is borne by the frontal, but a smaller tubercle below it is developed at the junction of the lacrymal with the jugal. In *Sciurus* this becomes the main tubercle. In *Castor* (Fig. 127) the great development of the anterior slip of the masseter and the correlated growth of the anterior part of the zygoma have displaced the orbit dorsad, so that the very small portion of the lacrymal which remains on the surface faces upward, forward, and outward. The tubercle is borne by the frontal. In the Geomyidæ the maxilla has usurped the place of the jugal in the anterior zygomatic plate and the jugal is limited to the middle of the zygomatic arch, the maxilla has also extended dorsad to the fronto-premaxillary junction, crowding the lacrymal into a more or less reduced condition; it, however, still bears the tubercle.

Similar conditions obtain in *Fiber* and *Mus* where the lacrymal is greatly reduced to a thin plate of bone on the inner wall of the orbit, above the infraorbital fenestra. In *Mus* it ends above in a delicate tubercle. In these and other myomorphs (Fig. 128) the final stages in the reduction of the lacrymal may perhaps be associated with the anterior extension of the medial slip of the masseter, which has worked its



Figs. 125 to 130. Skulls of Rodents. Subclass Placentalia, order Rodentia.

125. *Paramys copei*. Suborder Sciuromorpha, family Ischyromyidae. Lower Eocene, Lambdotherium zone, Wind River basin, Wyoming.
 126. *Arctomys* sp. Suborder Sciuromorpha, family Sciuridae.
 127. *Castor canadensis*. Suborder Sciuromorpha, family Castoridae.
 128. *Lophiomys imhausi*. Suborder Myomorpha, family Cricetidae.
 129. *Pedetes castor*. Suborder Dipodomorpha, family Pedetidae.
 130. *Hydrochoerus capybara*. Suborder Hystriomorpha, family Caviidae, subfamily Hydrochoerinae.

way forward above the infraorbital canal, pushing in the medial wall of the nasal chamber and finally appearing on the side of the rostrum in front of the orbit. However, it should be noted that the lacrymal was already reduced in the Oligocene *Ischyromys*, in which the medial extension of the lacrymal may have barely begun.

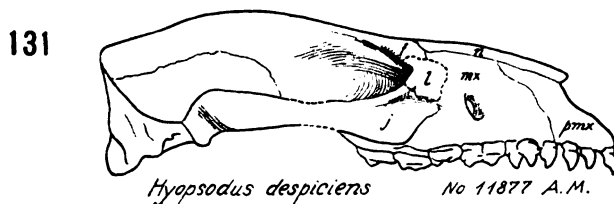
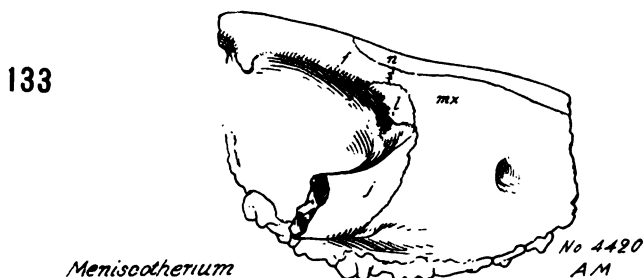
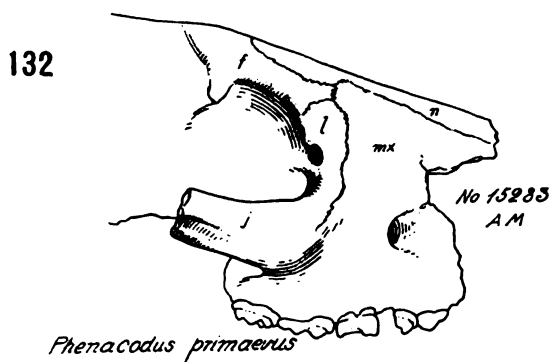
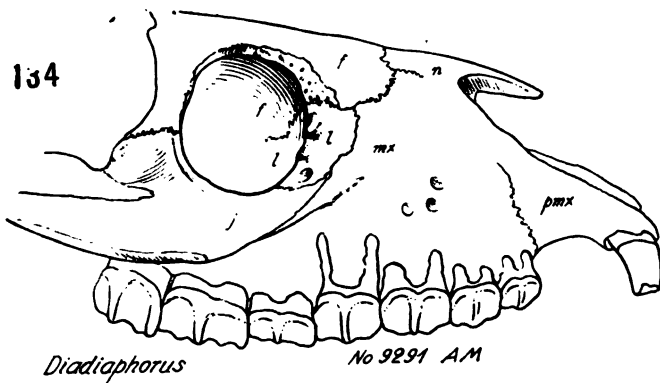
In *Pedetes* (Fig. 129) and allied types this medial slip of the masseter attains enormous dimensions, widely opening up the infraorbital fenestra; but in this group the lacrymal not only retains its place on the anterior rim of the orbit, but, together with the maxilla, plays an important part in transmitting dorsad thrusts from the zygoma to the frontal and to the alveolar process of the maxilla.

Somewhat similar conditions prevail in *Hydrochaerus* (Fig. 130) and allied genera of the Hystricomorpha; but here the lacrymal enjoys a marked secondary expansion, becoming a massive dorsal keystone to the zygomatic arch. The jugal is now restricted to the middle of the arch, and the lacrymal duct is exposed in the dried skull.

Lagomorpha

In *Lepus* and other Lagomorpha the lacrymal is a compressed bone on the anterior wall of the orbit, ending laterally in a large projecting tubercle. It is pierced by the lacrymal duct and is in contact with maxilla, palatine, and frontal. The jugal is fused at an early age with the zygomatic process of the maxilla (Lyon, 1904, p. 345) and is widely separated from the lacrymal (Amer. Mus. No. 9938). The premaxillæ are greatly extended dorsad and gain contact with the frontals as in other rodents. The prominent anterior rim of the orbit is formed exclusively by the maxilla.

The Lagomorpha date back at least to the Oligocene, and their direct ancestry in the Eocene is unknown. Mr. J. W. Gidley (1912) excludes the Lagomorpha altogether from the Rodentia on the grounds that the two groups were already widely separated in the Oligocene and that they differ in important characters of the jaws, dentition, and limbs. In support of this view one might cite the lagomorph resemblance of *Pachyrhukhos*, of the order Typotheria, which parallels the lagomorphs not only in the general form of the front teeth and jaws but in the adaptive facies of the auditory region. Nevertheless, the peculiar specializations of the lagomorph skull mask, but do not obliterate, a long series of characters which they have probably inherited from some such very primitive rodent as *Paramys*, in which the lacrymal was already reduced to a small bone on the anterior rim of the orbit.



Figs. 131 to 134. Skulls of two Condylarths (subclass Placentalia, order Condylarthra) and of a Litoptern (subclass Placentalia, order Litopterna).

131. *Hyopsodus despiciens*. Family Hyopsodontidae. Middle Eocene, Upper Bridger. Uintatherium zone, Bridger Basin, Wyoming. After Matthew.
 132. *Phenacodus primaevus*. Family Phenacodontidae. Lower Eocene, Coryphodon zone, Gray Bull beds, Bighorn basin, Wyoming.
 133. *Meniscotherium chamense terrarubra*. Family Meniscotheriidae. Lower Eocene, Meniscotherium zone, Largo beds, San Juan basin, New Mexico.
 134. *Diadiaphorus* sp. Order Litopterna, family Protheroheriidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.

Condylarthra

In the members of this order the lacrymal region is very primitive, recalling that of the creodonts, and affording a structurally ancestral stage for the various lines of specialization seen in the different orders of ungulates. In *Phenacodus* and *Meniscotherium* the lacrymal forms a short rim on the anterosuperior margin of the orbit; the tubercle is prominent and is directed downward and backward. The pars facialis is exposed dorsally, the pars orbitalis well developed. Above the lacrymal there is a fronto-maxillary contact of moderate (*Phenacodus*) or slight (*Meniscotherium*) width; the nasals extend well behind this point, as in perissodactyls. The lacrymal foramen is internal and the lacrymal is in contact below with the well-developed jugal.

In *Hyopsodus* (Fig. 131), which has been shown by Matthew (1915) to be a primitive condylarth, the lacrymal has a moderately extended pars facialis and the foramen is within the orbital margin (Matthew, 1909, Figs. 103, 104).

Litopterna

In this order the configuration of the lacrymal region, as well as of the whole skeleton, has probably been derived from the more primitive conditions represented in the Condylarthra. In *Diadiaphorus* (Fig. 134) of the Santa Cruz formation the lacrymal forms a well-marked rim on the anterior margin of the orbit and the pars facialis is extended dorsally. The pars orbitalis is well developed. The main lacrymal foramen is located within the orbit, medial to the orbital rim. Another and external foramen, in the pars facialis above the jugal, leads into a duct which is probably a branch of the main lacrymal duct (? inferior canaliculus). This second, or external, foramen is figured by Professor Scott also in *Licaphrium*, *Thoatherium*, and *Theosodon* (1910, XVII) and may also be seen in skulls in this Museum. In *Diadiaphorus* there are two fairly stout tubercles for the palpebral ligaments on the anterior rim of the orbit, the upper one being the larger. The infraorbital foramen is represented by three foramina, recalling the "foramina maxillo-facialia" of reptiles. The orbit is closed posteriorly by postorbital processes of the jugal and frontal, as it is also in *Licaphrium* and *Thoatherium*, but in *Theosodon* the postorbital projection of the jugal is wanting so that the orbit remains open posteriorly. In this genus the marked retraction of the nasals has not greatly affected the lacrymal. The pars facialis of the lacrymal is moderately developed and the orbital rim is very prominent, bearing a low tubercle.

In its successor, *Macrauchenia*, the anterior nares are entirely dorsal, above the eyes, and the narial passage leads straight downward; at the same time the rostrum is produced forward and the nasals are greatly abbreviated. Notwithstanding these specializations, which suggest the conditions in tapirs and in sea-elephants, the lacrymal region is but little modified. As the orbits are behind the last molar, the pars facialis is somewhat lengthened.

Entelonychia

The older members of this group are probably in many respects the most primitive of the notoungulate series. The lacrymal of *Homalodonto-*

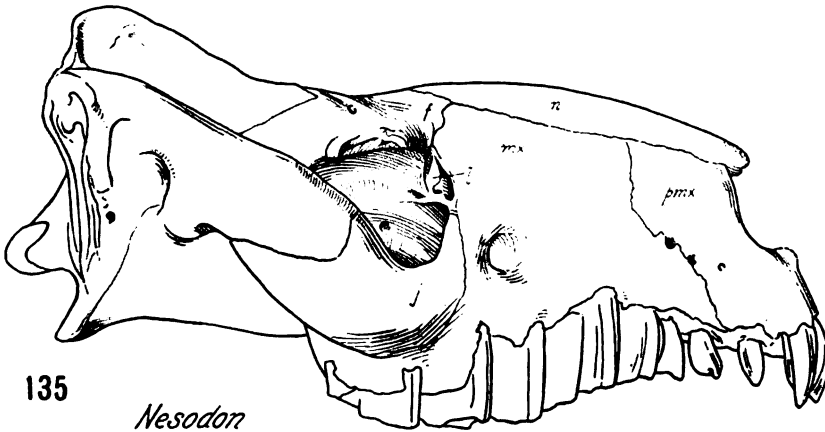


Fig. 135. *Nesodon imbricatus*. Subclass Placentalia, order Notoungulata, suborder Toxodonta, family Toxodontidæ. After Scott.

therium is thus described by Professor Scott (1912, p. 266): "The lacrymal, the limits of which are not easy to make out in either of the skulls, is, to all appearance, a very small triangular bone, without spine, which is exposed at the superoanterior margin of the orbit; the foramen is not visible from the side." The ascending process of the maxilla overlaps the frontals.

Astrapotheria

In *Astrapotherium*¹ the pars facialis of the lacrymal has been crowded out through the backward and upward retraction of the nasals and the concomitant development of the proboscis. The pars orbitalis bears a prominent swelling.

¹Cf. Fig. 21 of the succeeding paper on the preorbital fossæ of ungulates.

Toxodontia

In *Nesodon* (Fig. 135) the lacrymal is rather small and lies mostly within the orbit, the pars facialis being small. The foramen is marginal and there is a wide fronto-maxillary contact. A contact with the jugal is present. Essentially similar conditions obtain in *Toxodon*. In *Adinotherium*, as figured by Professor Scott (*op. cit.*, Pl. xx, fig. 1) the lacrymal is quite small.

Typotheria

Even among the older typotheres of the Santa Cruz formation the skull is already much specialized and two well-marked types of lacrymal region are presented.

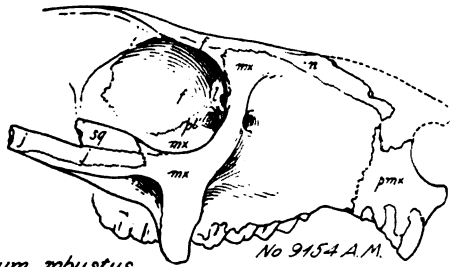
In the first type (*Hegetotherium*, Fig. 136) the lacrymal is comparatively primitive, retaining its normal position and contacts, although the pars facialis is secondarily enlarged, restricting the fronto-maxillary contact; the lacrymal bears the tubercle and the foramen is marginal. In this type the lacrymal forms a keystone which transmits thrusts from the stout zygomatic arch to the frontal and maxilla, the whole series of adaptations probably being connected with the great enlargement and anterodorsad extension of the masseter muscle. The great expansion of the angular region of the mandible, which is the insertion-area of the masseter, also testifies to the enlargement of the masseter, which was conditioned by the somewhat rodent-like modification of the incisors and the hypsodont form of the cheek-teeth.

In *Pachyrukhos* (Fig. 137), a structural derivative of *Hegetotherium*, the anterior end of the masseter must have extended still further dorsad in front of the orbit, carrying the mandible with it and restricting not only the pars facialis of the lacrymal but also the fronto-maxillary contact.

The final stage is attained in *Typotherium*, in which the incisors are of gnawing type. Here the pars facialis of the lacrymal is restricted to the anterior margin of the orbit; but in all these forms the jugal retains contact with the lacrymal.

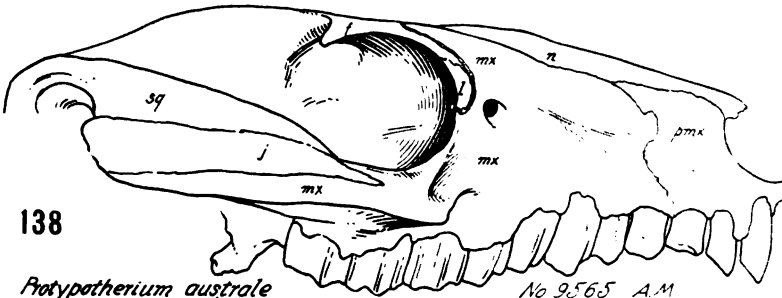
In the second series of typotheres (Figs. 138, 139), of the family Interatheriidae, the jugal is widely separated from the lacrymal and confined to the middle of the zygomatic arch, its place on the anterior border of the orbit being usurped by the maxilla. In this case the anterior end of the masseter fascia was doubtless produced sharply downward, much as in glyptodonts. In this series the lacrymal becomes reduced in size and barely extends to the lateral border of the orbit.

139

*Interatherium robustus*

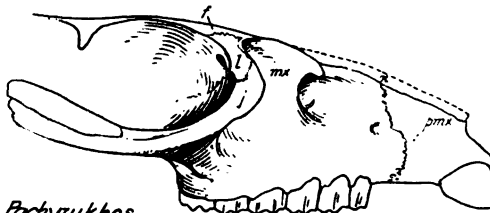
No 9454 A.M.

138

*Protypotherium australe*

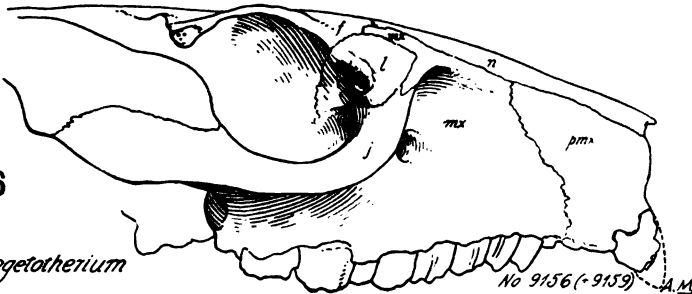
No 9565 A.M.

137

*Pachyrukhos*

No 14520 A.M.

136

*Hegetotherium*

No 9156 (-9159) A.M.

Figs. 136 to 139. Skulls of Notoungulata. Subclass Placentalia, order Notoungulata, suborder Typotheria.

136. *Hegetotherium mirabile*. Family Hegetotheriidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.
 137. *Pachyrukhos moyani*. Family Hegetotheriidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.
 138. *Protypotherium australe*. Family Interatheriidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.
 139. *Interatherium robustus*. Family Interatheriidae. Middle (?) Miocene, Santa Cruz formation, Patagonia.

Amblypoda

(Taligrada + Amblypoda, s. s.)

In *Haploconus* (Fig. 140) the lacrymal is rather small and forms the anterior rim of the orbit; the foramen is marginal and opens backward; there is no preorbital extension of the lacrymal; there is a well-developed fronto-maxillary contact which excludes the lacrymal from the nasals. The lacrymal articulates with the frontal, maxillary, jugal, and probably with the palatine. The whole orbital region is extremely primitive, differing from the condylarth type chiefly in the small size of the pars facialis.

In *Ectoconus* the relations of the lacrymal are the same as in *Haploconus*. In *Pantolambda* the lacrymal is of moderate size and forms the anterior rim of the orbit. There is no pars facialis. The maxillo-frontal contact is wide.

Even in the highly specialized *Uintatherium* (Fig. 141) there is no pars facialis, the lacrymal being entirely within the orbit (Marsh, 1872, Pls. I, II) where it is appressed to the inner wall. The foramen faces externally. The normal contacts with the frontal, maxilla, and jugal are retained.

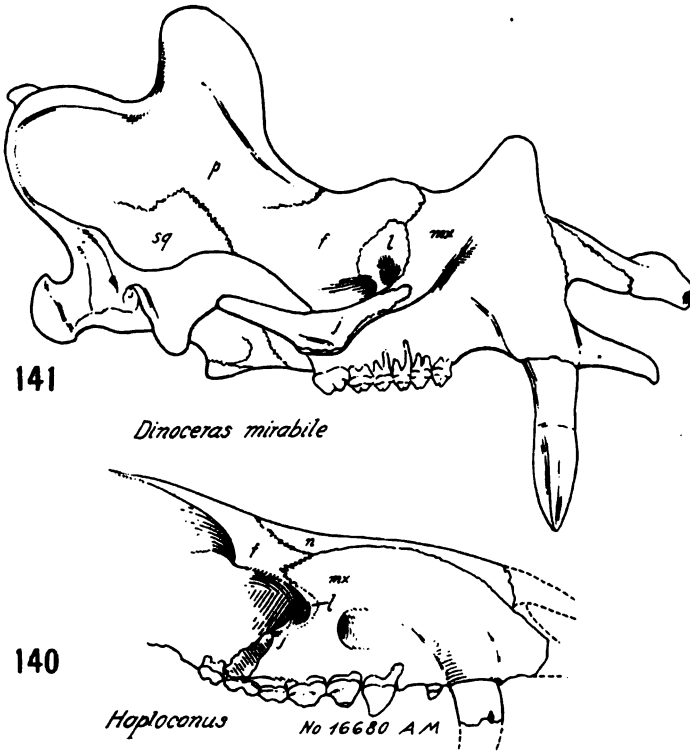
Proboscidea

In the Upper Eocene *Mærittherium* (Fig. 142) the position and limits of the lacrymal are not known. In one specimen "there is on the edge of the orbit a small tubercle presumably borne on the lacrymal, but there is no evidence of a lacrymal foramen" (Andrews, 1906, p. 103). The eyes are very far forward. The jugal is separated from the lacrymal by the maxilla. The orbital region is much more primitive than that of other Proboscidea, and suggests the sirenian type.

In *Palæomastodon* the lacrymal is a "small bone wedged between the frontal and maxilla and grooved below by the upper surface of the antorbital canal. It is perforated by a large foramen which lies within the border of the orbit; above the foramen and on the rim of the orbit there is a small but prominent tubercle" (Andrews, 1906, p. 138). The maxilla usurps the place of the jugal below the orbit and widely separates the lacrymal from the jugal. There is no pars facialis. The lacrymal has perhaps been restricted by the recession of the nares and the crowding back of the trunk muscles.

In *Mastodon americanus* (Fig. 145) the lacrymal is rather widely extended on the inner wall of the orbit. The foramen is on the anterior wall of the orbit near the junction of the lacrymal with the maxilla. The latter widely separates the jugal from the frontal.

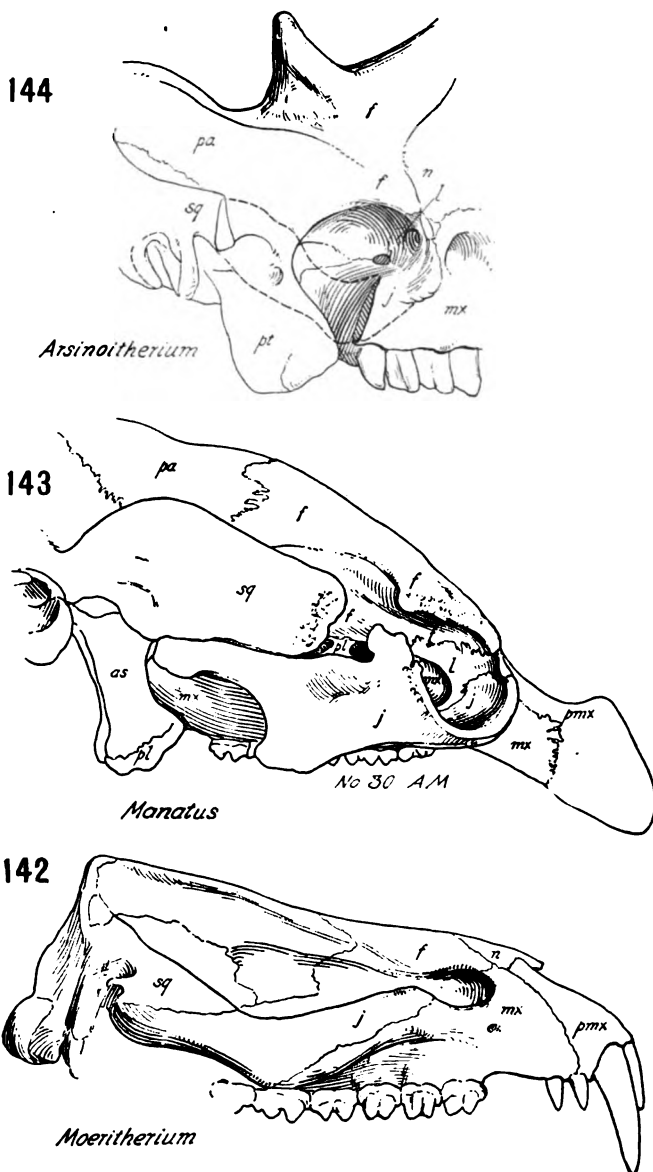
In modern elephants (Fig. 146) the lacrymal is rather small and has no pars facialis. It forms the anterior rim of the orbit and has a moderate orbital expansion. The stout tubercle serves for the attachment of the palpebral ligament and the lacrymal is surrounded by the robust orbicularis muscles. (See the dissections in Boas and Paulli, 1908.) The maxillo-frontal contact is wide. The foramen and canal are absent,



Figs. 140, 141. Skulls of Amblypoda. Subclass Placentalia, order Amblypoda.

140. *Haploconus lineatus*. Suborder Taligra, family Periptychidae. Paleocene, Polymastodon zone, Puerco formation, San Juan basin, New Mexico.
 141. *Dinoceras mirabile*. Suborder Dinocerata, family Uintatheriidae. Middle Eocene, Uintatherium zone, Upper Bridger, Bridger basin, Wyoming. After Marsh.

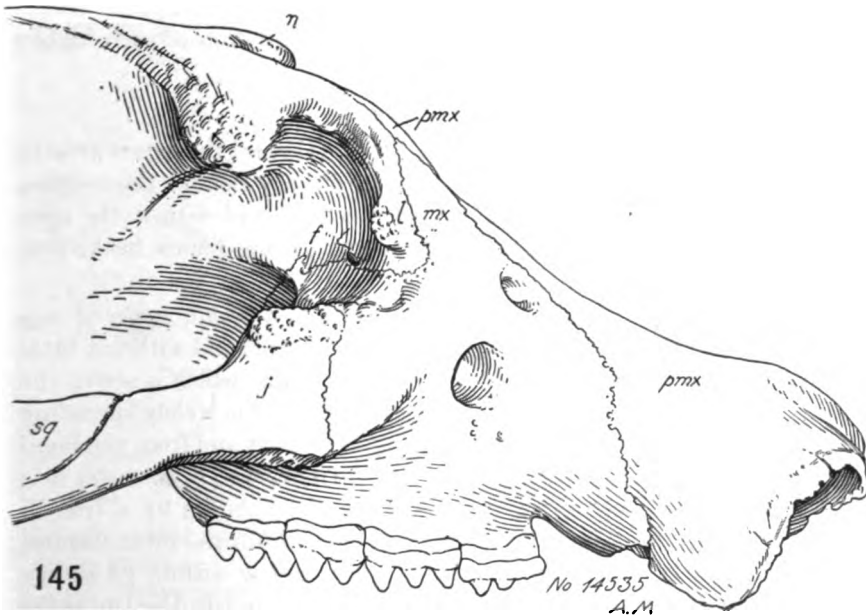
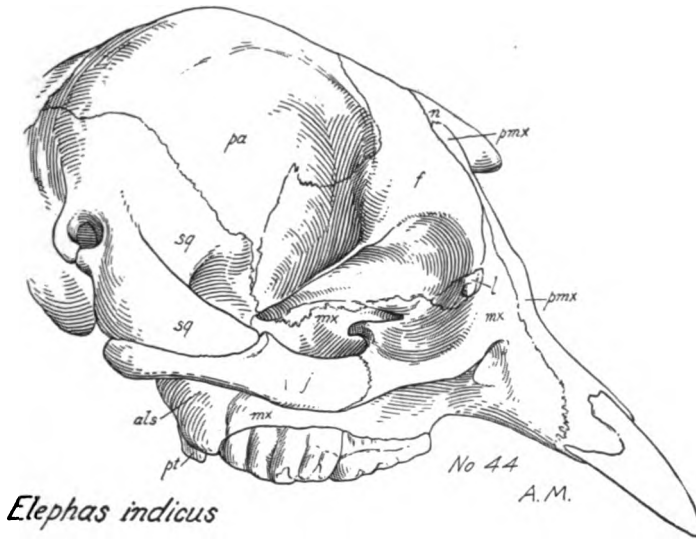
and likewise the lacrymal gland (Weber, 1904, p. 719). The lacrymal has been less affected by the development of the trunk than have many other elements of the skull.



Figs. 142 to 144. Skulls of *Mœritherium*, *Manatus* and *Arsinoitherium*. Sub-class Placentalia, orders Proboscidea, Sirenia, Embrithopoda.

142. *Mœritherium lyonsi*. Order Proboscidea, family Mœritheriidae. Upper (?) Eocene, Quasar-el-Sagha beds, Fayûm, Egypt. After Andrews.
143. *Manatus latirostris*. Order Sirenia, family Manatidae.
144. *Arsinoitherium sitlei*. Order Embrithopoda, family Arsinoitheriidae. Lower Oligocene, Fluvio-marine beds, Fayûm, Egypt. After Andrews.

146



Figs. 145, 146. Skulls of Proboscidea. Subclass Placentalia, order Proboscidea.
 145. *Mastodon americanus*. Family Mastodontidae. Pleistocene, Indiana.
 146. *Elephas indicus*. Young skull. Family Elephantidae.

Sirenia

The lacrymal of *Eosiren* is not known.

In *Manatus* (Fig. 143) the lacrymal is extended anteroposteriorly on the inner wall of the orbit. No lacrymal duct is visible, and Murie found no lacrymal gland present (Weber, 1904, p. 733). The jugal retains contact with the lacrymal, whereas in the Proboscidea it is widely removed from it.

In the dugong (*Trichechus*) and in *Rhytina* the lacrymal is thickened on the anterior rim of the orbit.

Embrithopoda

The lacrymal of *Arsinoitherium* (Fig. 144) is described by Dr. Andrews (1906, p. 7) as follows:

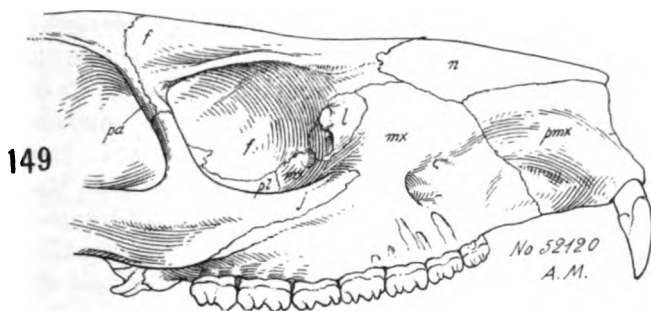
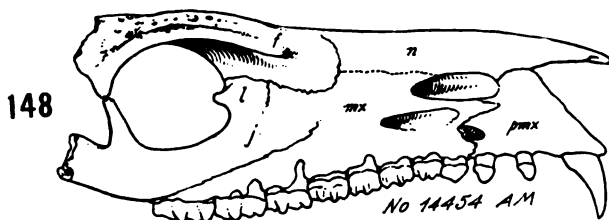
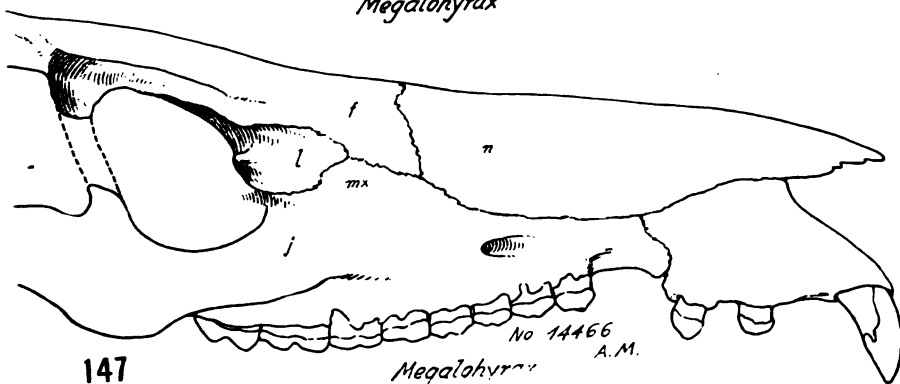
The lacrymal is a small bone occupying the anterior angle of the orbit, wedged in between the frontal above, and the maxilla and jugal below. It bears a vertically-elongated prominence (see Pl. I, l), which forms the actual edge of the orbit and is connected below with a strong crest borne on the front of the maxillary process of the jugal. There seems to be no trace of any lacrymal foramen.

It is rather interesting to find the lacrymal of this animal maintaining so much of its primitive character and position in such highly specialized surroundings.

Hyracoidea

In the Upper Eocene *Megalohyrax* (Figs. 147-148) the face is greatly prolonged in front of the orbits which lie mostly behind the molars. The fronto-maxillary contact is widely extended and with it the pars facialis of the lacrymal. The stout lacrymal spine points backward. Contact with the jugal is retained.

In *Dendrohyrax* (Fig. 149) the lacrymal is a small, more or less quadrilateral bone at the anterior corner of the orbit and with but little orbital expansion. It bears a very prominent spine, which is above the crista anterior of the maxilla. It is separated from the widely spreading nasal by a small to moderate maxillo-frontal contact and from the jugal by the crista anterior of the maxilla. On the inner wall of the orbit it is widely separated from the vertical plate of the palatine by a fronto-maxillary contact. The large foramen is well within the orbit, behind and below the spine. The lacrymal is quite hollow within, its cavity opening anteriorly into the maxillary antrum, lateral to the turbinate bones. The bony naso-lacrymal duct is supported by laminae from the lacrymal and maxilla. Beginning at the lacrymal foramen it turns sharply inward and slightly downward running in toward the ethmoid

*Dendrohyrax**Megalohyrax**Megalohyrax*

Figs. 147 to 149. Skulls of Hyracoidea. Subclass Placentalia, order Hyracoidea, family Hyracidae.

147. *Megalohyrax* sp. Subfamily Saghatheriinae. Lower Oligocene, Fluvio-marine beds, Fayûm, Egypt.
 148. *Megalohyrax* sp. Subfamily Saghatheriinae. Lower Oligocene, Fluvio-marine beds, Fayûm, Egypt.
 149. *Dendrohyrax* sp. Subfamily Hyracinae (Procaviinae).

beneath the ethmo-turbinals. It then turns forward coursing along the inner side of the maxilla and premaxilla and opens below a curved lamina on the inner side of the premaxilla above the enlarged incisor.

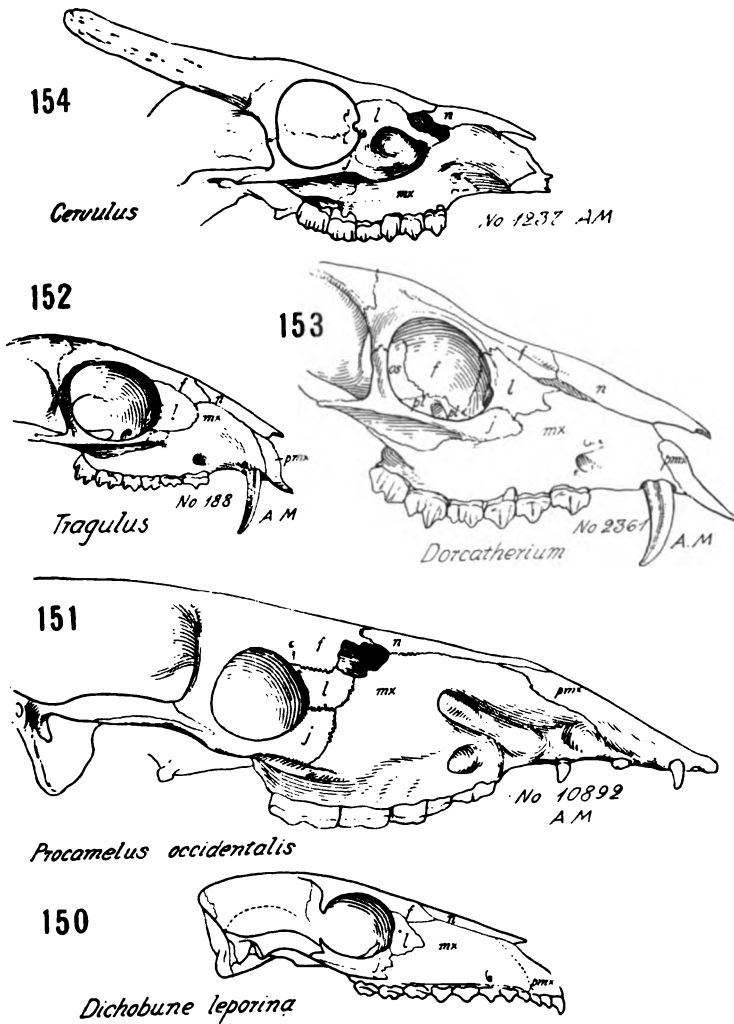
In *Procavia* the lacrymal is less quadrilateral in form, its orbital extension being more covered by the frontal and maxilla. It is set more obliquely, running anterosuperiorly into a point. Its prominent spine is directed downward and backward, rather than outward. It sometimes has contact with the nasal and separates the frontal from the maxilla, but usually it is excluded from the nasals by a small fronto-maxillary contact. It is separated from the jugal by a strip of the maxilla which is of varying width, sometimes very narrow, so that the jugal very nearly reaches the lacrymal. Its ample duct runs sharply downward and forward enlarging in its descent and opening widely below into the nasal tract, behind the anterior palatine foramen. Thus the two living genera of hyracoids exhibit rather wide differences in the lacrymal region.

Artiodactyla

In this order the lacrymal primitively forms the sharp anterior rim of the orbit and the extension of the preorbital part of the lacrymal (*pars facialis*) early attained an extreme. In modern forms this facial part serves as a base for the orbicular muscles and is correlated with a forward continuation of the inner canthus of the eye and with outwardly directed eyes.¹ The expanded lacrymal also serves in part for the attachment of the maxillo-labialis superior and naso-labialis muscles, and sometimes its external surface is depressed by a large facial gland.

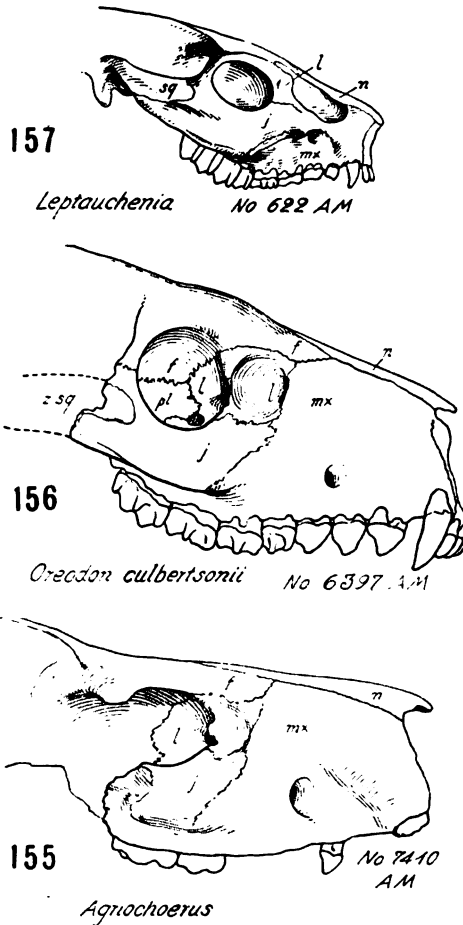
The lacrymal region in the Eocene *Dichobunidae* (Fig. 150) has been carefully figured by Stehlin (1906) and is well shown in an uncrushed skull of *Homacodon vagans* in this museum. These forms suggest *Tupaia* and *Myrmecobius* in the swollen and tubular character of the preorbital part of the face and in the way that the lacrymals form the anterior rim of the orbits and project laterally in the top view. The *pars facialis* is well developed. The tubercle is marginal and the foramen is medial to it, behind the anterior orbital rim. There is a wide maxillo-frontal contact. The nasals do not spread widely in the top view but are narrowed proximally by the fronto-maxillary contact. Such are the conditions in *Dichobune* and *Tapirulus* according to Stehlin's figures, but in *Mixtotherium* the lacrymal as provisionally restored in Stehlin's figure is much reduced.

¹See the dissections given by Boas and Paulli, Windle and Parsons, Cuvier and Laurillard.



Figs. 150 to 154. Skulls of Artiodactyls. Subclass Placentalia, order Artiodactyla.

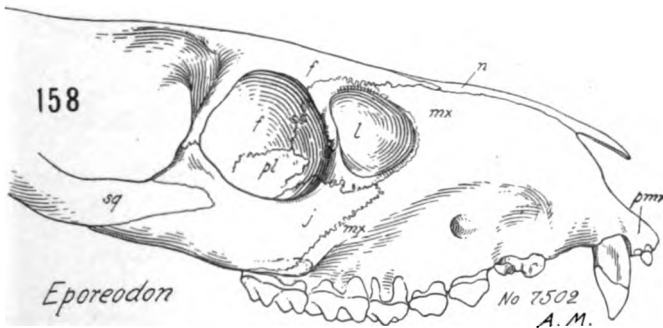
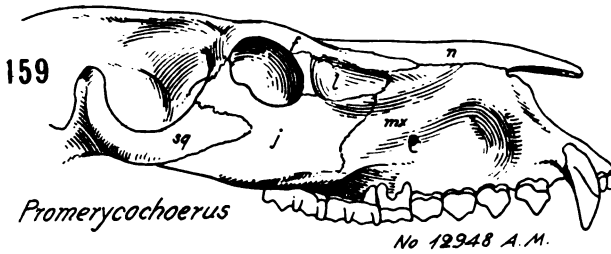
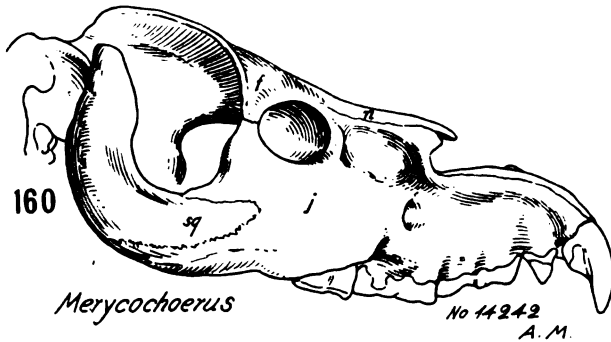
150. *Dichobune leporina*. Family Dichobunidae. Upper Eocene (Upper Ludien), Phosphates of Quercy, France, After Stehlin.
 151. *Procamelus occidentalis*. Family Camelidae. Upper Miocene, Procamelus zone, Little White River, South Dakota.
 152. *Tragulus* sp. Family Tragulidae.
 153. *Dorcatherium* sp. Family Tragulidae.
 154. *Cervulus* sp. Family Cervidae.



Figs. 155 to 157. Skulls of Oreodonts. Subclass Placentalia, order Artiodactyla, family Oreodontidæ.

- 155. *Agriochoerus trifrons*. Upper Oligocene, John Day formation, Oregon.
- 156. *Oreodon culbertsonii*, var. *periculatorum*. Middle Oligocene, Oreodon zone, Brule formation Cedar Creek, northeastern Colorado.
- 157. *Leptauchenia decora*. Upper Oligocene, Protoceras zone, Upper Brule formation, South Dakota.

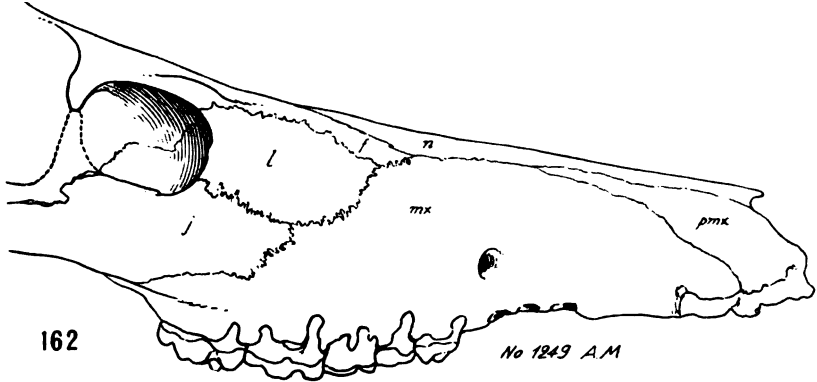
Among the Oreodontidæ (Figs. 155-160) the conditions of the lacrymal region might readily be derived from those in the Dichobunidæ. The pars facialis now bears a wide depression for a facial gland, the



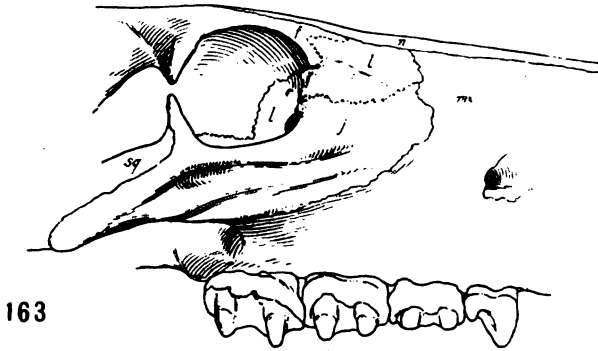
Figs. 158 to 160. Skulls of Oreodonts (continued).

158. *Eporeodon occidentalis* var. *pacificus*. Upper Oligocene, John Day formation, Oregon.
 159. *Promerycochærus* sp. Lower Miocene, Promerycochærus zone, Arikaree formation, Lower Rosebud beds, South Dakota.
 160. *Merycochærus* sp. Lower Miocene, Arikaree formation, Merycochærus zone, Upper Harrison beds, Nebraska.

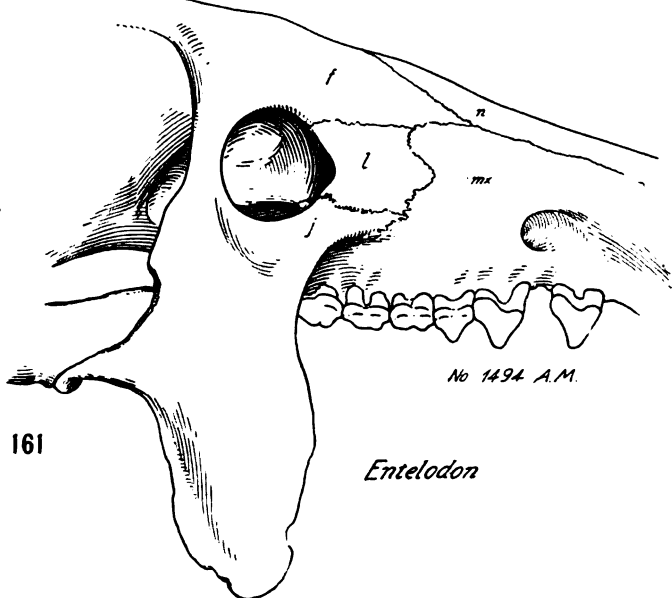
foramen is internal, the nasals narrow proximally, and there is a wide maxillo-frontal contact. In *Agriochærus* similar conditions obtain. In *Merychys* the anterior apophysis of the frontal is long and thin, lying between the expanded lacrymal and the nasals.



Ancodon brachyrhynchus



Hippopotamus lemerlei

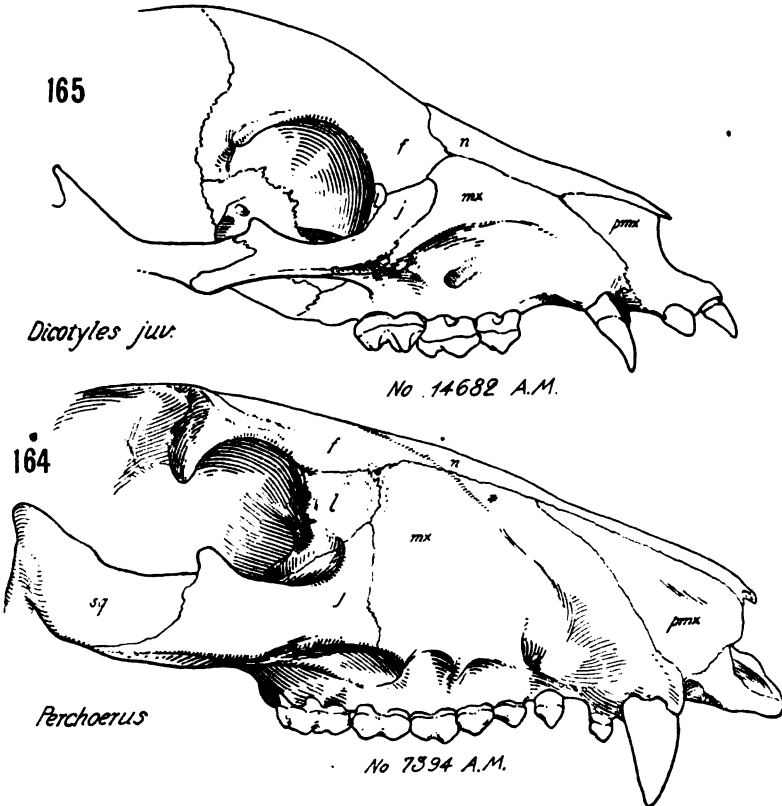


Entelodon

Figs. 161 to 163. Skulls of pig-like Artiodactyls. Subclass Placentalia, order Artiodactyla.

161. *Entelodon* sp. Family Entelodontidae (Elotheriidae). Middle Oligocene, Oreodon zone, Brule, formation, South Dakota.
162. *Ancodon brachyrhynchus*. Family Anthracotheriidae. Upper Oligocene, Protocreos zone, Brule formation, South Dakota.
163. *Hippopotamus lemerlei*. Family Hippopotamidae. Pleistocene, Madagascar.

Among the Anthracotheriidae, *Ancodon brachyrhynchus* (Fig. 162) has an extremely long facial extension of the lacrymal, surmounted by even longer anterior apophyses of the frontals. The nasals narrow at the proximal end. In *Heptacodon*, on the contrary, the spreading proximal



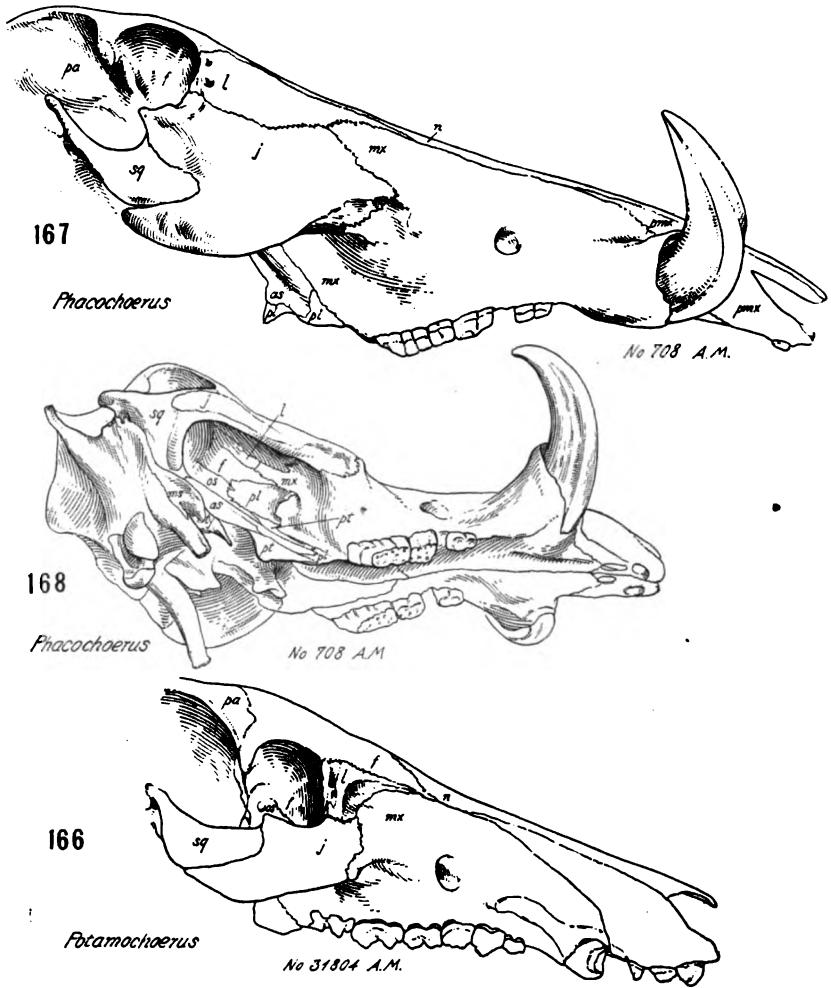
Figs. 164, 165. Skulls of *Perchoerus* and *Dicotyles*. Subclass Placentalia, order Artiodactyla, family Dicotylidae.

164. *Perchoerus pristinus*. Upper Oligocene, Diceratherium zone, John Day formation, Oregon.

165. *Dicotyles* (= *Tayassu*) *pecari*. Young skull with milk teeth.

ends of the nasals are exposed dorsally and extend toward the lacrymals, being perhaps still separated therefrom by a narrow isthmus of the frontal apophysis.

The Hippopotamidae (Fig. 163) are believed by Dr. C. E. Andrews (1906, p. xx) to have been derived from the Anthracotheriidae and their lacrymal region apparently offers nothing inconsistent with this view.



Figs. 166 to 168. Skulls of *Potamochoerus* and *Phacochoerus*. Subclass Placentalia, order Artiodactyla, family Suidæ.

166. *Potamochoerus* sp. Subfamily Suinæ.

167. *Phacochoerus*. Subfamily Phacochoerinae.

168. Same skull as in Fig. 167, oblique lower view to show the relations of the lacrimal to the surrounding elements.

The lacrymal has an extended pars facialis, which has gained wide contact with the nasal and widely separates the frontal from the maxilla.

The lacrymal region of the elotheres (Entelodontidæ, Fig. 161) exhibits little of note. There is a wide fronto-maxillary contact and an extensive pars facialis. Among the Dicotylidæ, *Perchærus* (Fig. 164) shows a primitive condition of the lacrymal region. In the modern peccaries, however, the lacrymal is much reduced in size and is overlapped by the jugal. The lacrymal still bears the tubercle and is in contact with jugal, maxilla and frontal. There is a prominent foramen, between the lacrymal and the frontal, that leads into the nasal cavity, but it may be the sphenopalatine rather than the lacrymal foramen, as Weber (1904, p. 651) says that the lacrymal foramen of the peccary is absent.

Among the Suidæ (Figs. 166-168), *Phacochærus* especially has a very widely extended pars facialis. In *Sus* the lacrymal is said to be shorter in domesticated races (Pira, quoted by Hilzheimer, 1918) but the length of the lacrymal is independent of the length of the snout (*idem*).

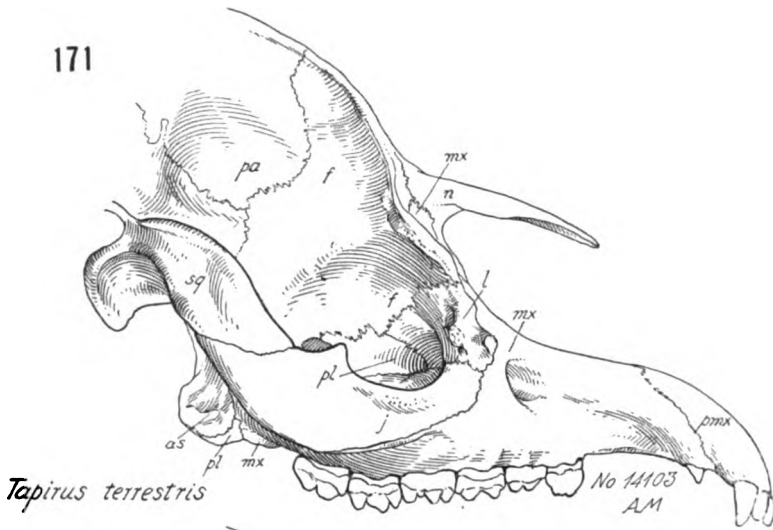
In the earlier Camelidæ (*Protylopus*, Scott, 1913, p. 399, fig. 212A) the pars facialis of the lacrymal is of moderate size, and the lacrymals are separated from the nasals by a fronto-maxillary contact. A slight vacuity is indicated between the nasal, lacrymal, frontal, and maxilla. Somewhat similar conditions obtain in *Procamelus* (Fig. 151). In the modern *Camelus* the proximal ends of the nasals become extraordinarily wide, replacing the fronto-maxillary contact, and are in contact with the lacrymals. The pars facialis is rather reduced and in the dried skull its anterior part is more or less replaced by a vacuity.

In the Pecora (Figs. 153, 154) the pars facialis of the lacrymal sometimes becomes very long as in the ox. It has the oblique position, running forward and inward from the orbit to the snout, which is clearly foreshadowed in *Oreodon*. It usually develops a vacuity at the antero-internal corner and is depressed externally by the facial gland. The maxillaries and frontals are widely separated an obvious specialization. The variations in the details of the lacrymal region in the Pecora have been used for systematic purposes by Dr. Knotterus Meyer (1907).

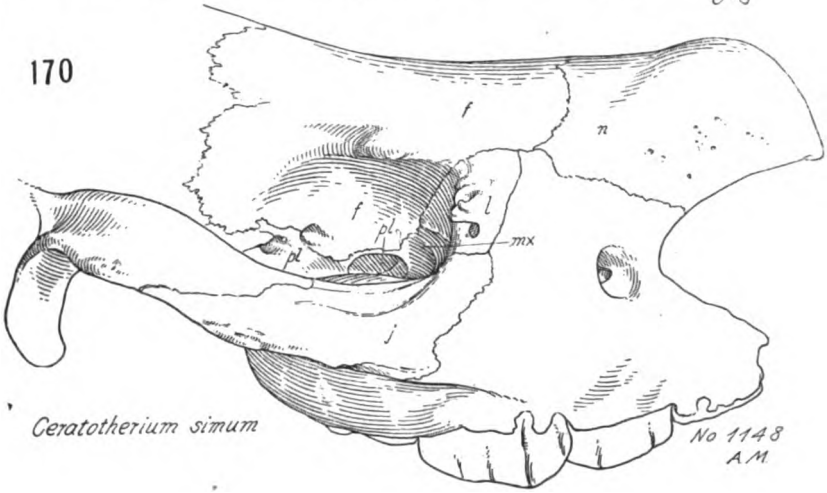
Perissodactyla

In *Mesohippus* the lacrymal is a flat squarish bone of moderate size located at the upper front margin of the orbit; it makes a wide contact with the spreading nasal and widely excludes the frontal from the maxillary. The maxillo-nasal contact does not extend much above the middle of the lacrymal.

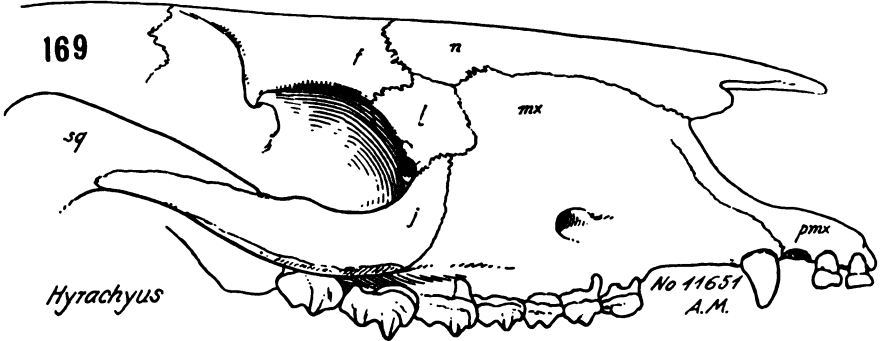
171

*Tapirus terrestris*

170

*Ceratotherium simum*

169

*Hyrachyus*

Figs. 169 to 171. Skulls of Perissodactyls. Subclass Placentalia, order Perissodactyla.

169. *Hyrachyus* sp. Superfamily Rhinocerotoidae, family Rhinocerotidae, subfamily Hyrachyinae. Middle Eocene, Lower Bridger, Orophippus zone, Bridger basin, Wyoming.

170. *Ceratotherium simum*. Family Rhinocerotidae. White rhinoceros. Young skull with milk teeth.

171. *Tapirus terrestris*. Family Tapiridae.

In the later Equidæ *pari passu* with the deepening of the face the lacrymal also expands in size, but the pars facialis always remains more or less square and never much resembles the elongate oblique pars facialis of the Artiodactyla. The foramen lies in the primitive position within the anterior margin of the orbit. The lacrymal and malar fossæ of the Tertiary Equidæ will be discussed in Number V of this series of studies.

As shown in Mr. S. H. Chubb's preparations, the wide nasals of the horse cover the expanded nasal and frontal sinuses. The expanded lacrymals protect the ethmoid region laterally. The lacrymal duct follows its primitive course along the inner side of the maxilla. In a zebra foal the lacrymal is relatively small.

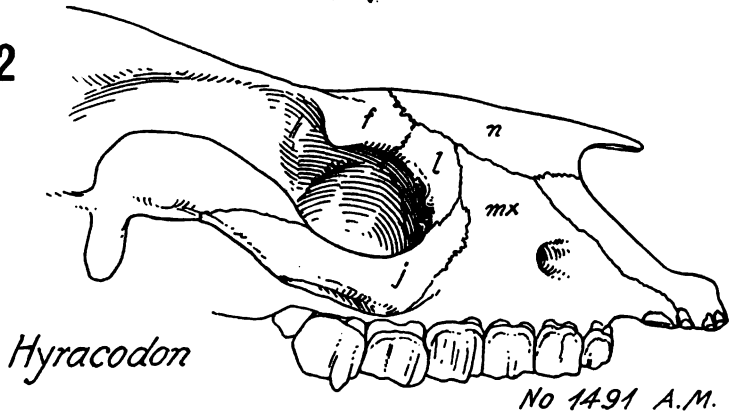
Among those Eocene perissodactyls which are allied both to *Eohippus* and to the ancestors of the Tapiridæ, *Systemodon* and *Isectolophus* have widely spreading nasals, which apparently were in contact and replaced the fronto-maxillary contact. The same was true of the palæotheres, of *Triplopus cubitalis*, which was perhaps allied to the Hyracodontidæ, and of *Hyrachyus* (Fig. 169), a primitive relative of the lophiodonts and rhinoceroses.

The lacrymal region is especially well shown in skulls of *Hyracodon* (Fig. 172). Here the lacrymal has a large contact with the nasals and widely excludes the frontals from the maxilla. The pars facialis is well developed. In *Colanoceros agrestis* Marsh the lacrymal had a well-developed pars facialis and was apparently in contact with the widely spreading nasals, the foramen was internal to the crista anterior of the orbit; a distinct but small tubercle is present just lateral to the foramen. Similar conditions are present in *Cænopus* (Fig. 173), a primitive rhinoceros, and in *Eomoropus* and *Moropus* of the Chalicotheriidæ. Hence it is evident that the early perissodactyls have a very distinctive lacrymal region which differentiates them from other ungulates with an expanded pars facialis.

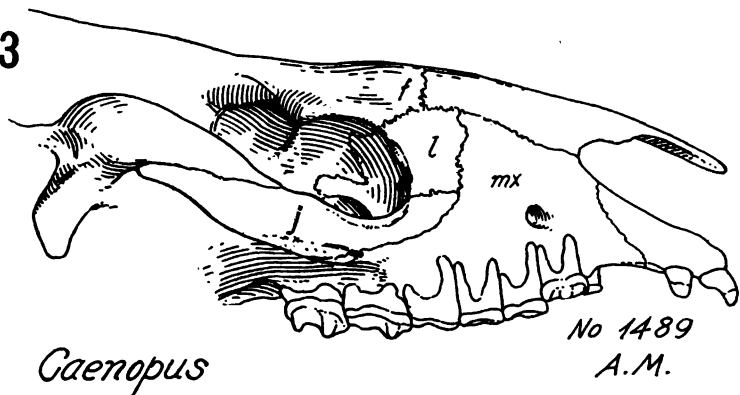
In the tapirs (Fig. 171) the recession of the naso-maxillary fissure backward and upward and the growth of the trunk muscles have conditioned the loss of the pars facialis of the lacrymal and of the lacrymo-nasal contact, the dorsal extension of the ascending process of the maxilla, and the consequent establishment of a new fronto-maxillary contact. These conditions are foreshadowed in the Miocene *Protapirus* but, in view of the apparent constancy of a naso-lacrymal contact in the earlier Perissodactyla, the opposite condition in the tapirs appears to be secondary.

So also the more specialized species of modern rhinoceroses, in spite of the wide naso-lacrymal contact of their early Tertiary predecessors, tend to lose this contact, apparently because the nasals become somewhat drawn forward under the horns, so that in both the Black Rhino-

172



173

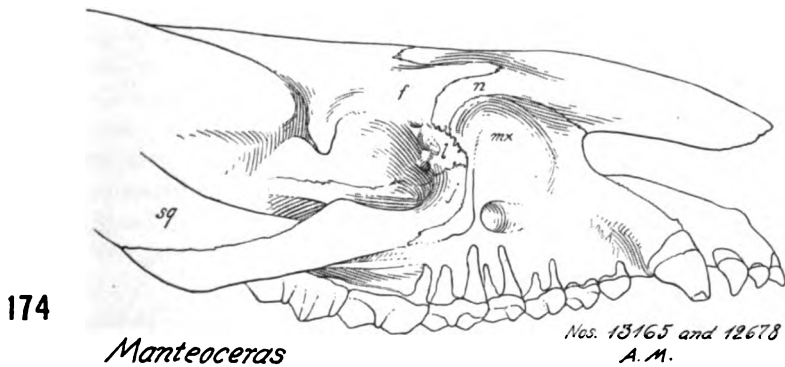
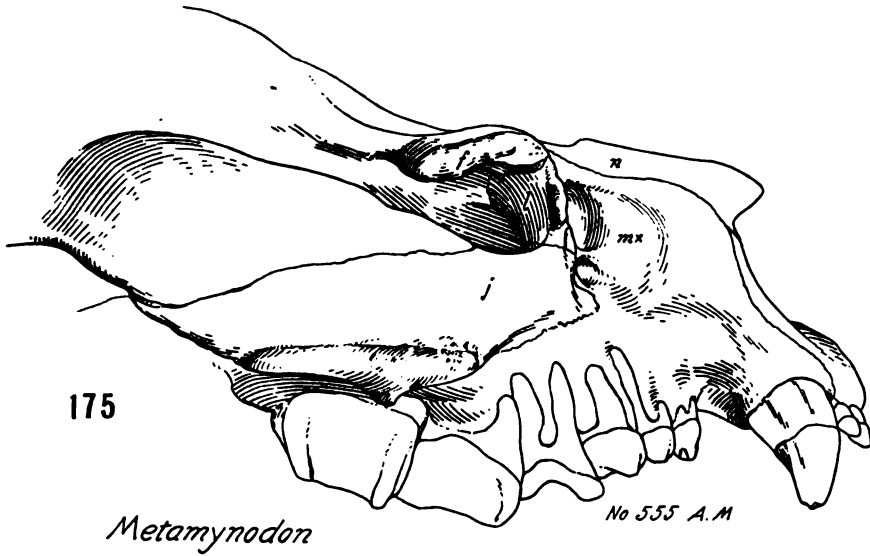


Figs. 172, 173. Skulls of *Hyracodon* and *Caenopus*. Subclass Placentalia, order Perissodactyla, superfamily Rhinoceroidea.

172. *Hyracodon nebrascensis*. Family Hyracodontidae, subfamily Hyracodontinae. Middle Oligocene, Oreodon zone, Brule formation, South Dakota.

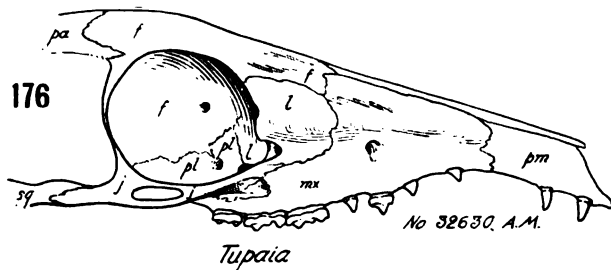
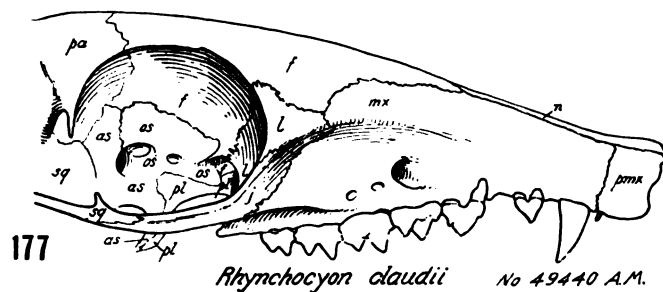
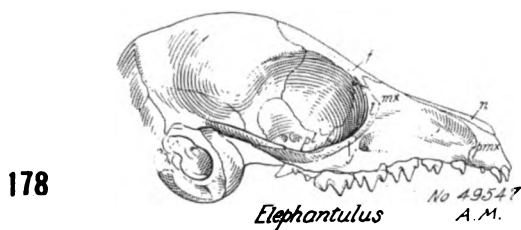
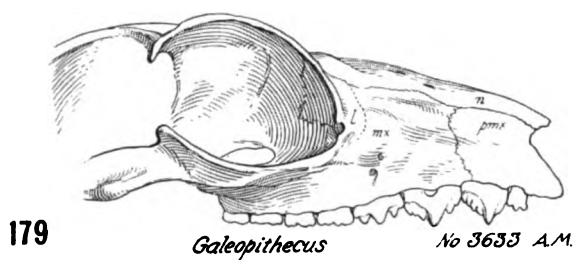
173. *Caenopus* (= *Subhyracodon*) *trigonodus*. Family Rhinocerotidae. Middle Oligocene, Oreodon zone, Brule formation, South Dakota.

ceros and the White Rhinoceros (Fig. 170) a slight fronto-maxillary contact is established even in very young skulls. The primitive *Rhinoceros sondaicus* retains the naso-lacrymal contact.



Figs. 174, 175. Skulls of *Manteoceras* and *Metamynodon*. Subclass Placentalia, order Perissodactyla.

174. *Manteoceras washakiensis*. Superfamily Brontotheroidea, family Brontotheriidae, subfamily Manteoceratinae. Middle Eocene, Lower Washakie, Uintatherium zone, Wyoming.
175. *Metamynodon planifrons*. Superfamily Rhinocertoidea, family Amynodontidae. Middle Oligocene, Oreodon zone, Lower Brule formation, South Dakota.



Figs. 176 to 179. Skulls of Tupaoids and *Galeopithecus*. Subclass Placentalia, orders Menotyphla, Dermoptera.

176. *Tupaia* sp. Order Menotyphla, family Tupaiidae, subfamily Tupainæ.

177. *Rhynchocyon claudii*. Order Menotyphla, family Macroscelididae.

178. *Elephantulus (Macroscelides)* sp. Order Menotyphla, family Macroscelididae.

179. *Galeopithecus* sp. Order Dermoptera, family Galeopithecidae.

Among the titanotheres all the numerous Eocene genera which have been investigated by Professor Osborn and the writer have proximally spreading nasals which are in contact with the lacrymals and exclude the frontal from contact with the maxilla. The lacrymal in all these animals forms the anterior rim of the orbit and has no pars facialis. The tubercle is prominent and the large duct is just within the border of the orbit (Fig. 174).

In the later titanotheres the anterior apophyses of the frontals partly overlap the nasals and with them give rise to the rapidly progressive "horns"; but the frontals never gain contact with the maxilla. The extreme development of the "horns" conditions the growth of a lateral supporting pillar in front of the eyes, which is formed from the nasals, frontals, lacrymals, and jugals.

Menotyphla

The tupaoid "insectivores" are widely removed from the true insectivores and are probably survivors of the pre-Tertiary ancestral lemuroid stock.¹ The group appears to be represented in the Lower Eocene by the Plesiadapidæ,² which are remotely allied to the Eocene lemuroids.

In the recent *Tupaia* (Fig. 176) the snout is more or less conical, the frontals, maxillæ, and lacrymals widely expanded, to cover the large, highly convoluted ethmoid scrolls. The orbit is deep and sharply rimmed by the jugal, lacrymal, and frontal. The lacrymal, as is usual in such cases, is prominently developed on the well-rimmed projecting margin of the orbit. It has a well-developed pars facialis, the tubercle is marginal and the foramen medial to the tubercle. There is a well-marked fronto-maxillary contact. In *Ptilocercus* the pars facialis bears a depression which is apparently for the preorbicularis muscle. The foramen is marginal, almost in front of the orbit; the lacrymal region as a whole is lemur-like (Gregory, 1910, Fig. 21, p. 273).

Among the Macroscelididæ the lacrymal region of *Rhynchocyon* (Fig. 177) agrees in essentials with that of *Tupaia*. The frontal region is even wider. There is a deep fossa for the maxillo-labialis superior on the side of the maxilla in front of the lacrymal. In *Macroscelides* and allied genera (Fig. 178) the anterior rim of the orbit is squeezed between

¹1910, Bull. Amer. Mus. Nat. Hist., XXVII, pp. 279, 280, 321, 322; 1913, Bull. Geol. Soc. Amer., pp. 247-252.

²1920, Mem. Amer. Mus. Nat. Hist., (N. S.) III, part 2. See also Matthew, W. D., 1917, Bull. Amer. Mus. Nat., XXXVIII, pp. 836-838.

the large eye and the facial muscles, and the marginal part of the lacrymal together with the pars facialis is much reduced.

Dermoptera

In *Galeopithecus* (Fig. 179), which may well be remotely related to the Menotyphla, the general conformation of the facial region is somewhat similar to that of *Rhynchocyon*, except that the whole muzzle is now very broad and more or less inflated. The orbits are sharply rimmed above and in front, the lacrymal giving a prominent orbital rim. The pars facialis is extended. The fronto-maxillary contact is reduced. The foramen is within the orbital rim.

Chiroptera

In the Microchiroptera sutures are very hard to make out but in a foetal specimen of *Saccolaimus peli*, kindly placed at my disposal by Mr. Herbert Lang, there is a vacuity on the inner wall of the orbit between the maxilla and the frontal, which may have been filled either by the lacrymal or by the os planum of the ethmoid. In an adult *Saccolaimus* the small lacrymal foramen is on the raised anterior rim of the orbit. There is certainly no pars facialis. The fronto-maxillary contact is large.

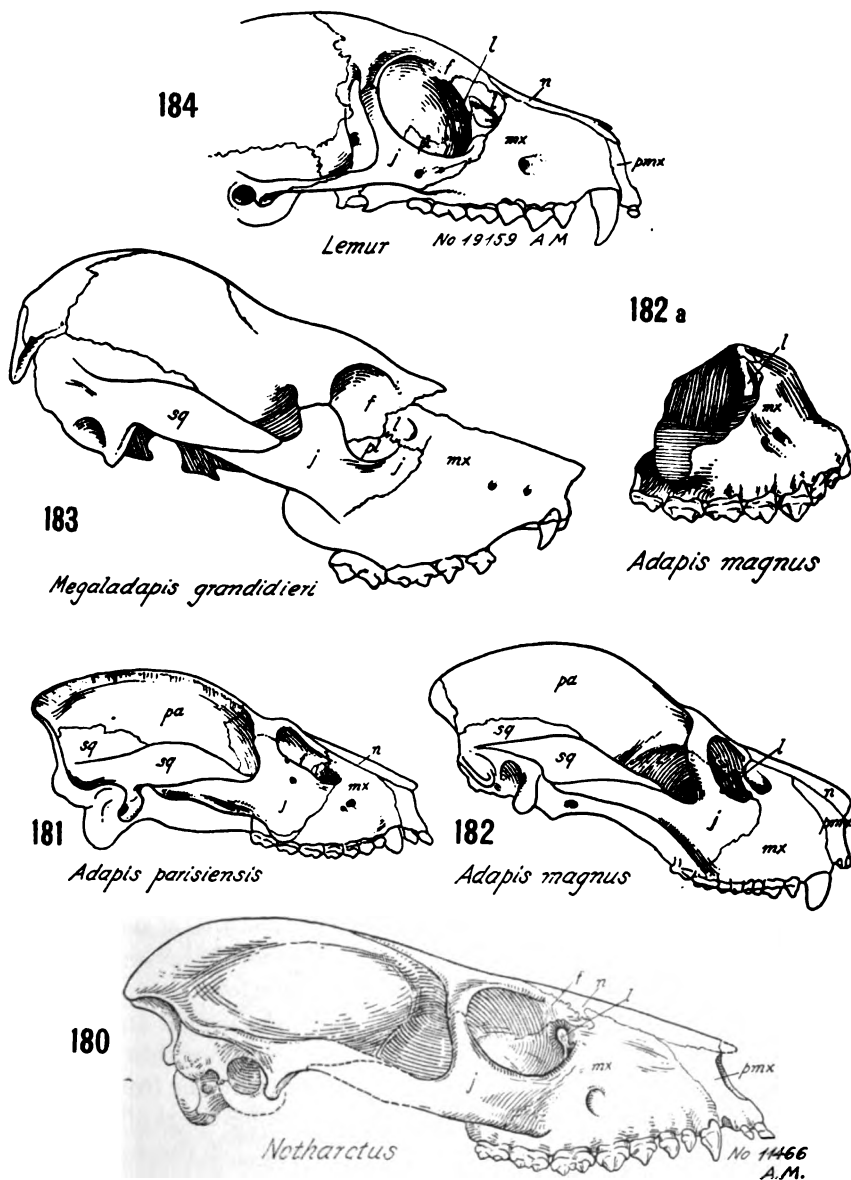
In the Macrochiroptera the lacrymal may readily be seen in young skulls. In *Eidolon helvum* it is a relatively large element crowded well forward so that it has but a small pars orbitalis, which is vertically extended and in contact with the frontal, the palatine, and the maxilla. The pars facialis is moderately extended and is separated from the pars orbitalis by a well-marked crista posterior. The pars facialis bears a large fossa leading into a prominent fissure at the antero-inferior corner of the lacrymal and between the lacrymal and the maxillary. There is also a very small lacrymal foramen on the posterior rim of the crista posterior. The lacrymal is widely separated from the jugal by the maxilla. There is a good fronto-maxillary contact.

Thus the lacrymal region of the Megachiroptera is rather similar to that of a modern *Lemur* and this is very possibly because in both these long-snouted forms the inner canthus of the eye has been shifted forward, extending the pars facialis and lacrymal foramen.

In the secondarily short-snouted *Myonycteris wroughtoni*, on the other hand, the pars facialis is short.

Primates

The lacrymal region (Fig. 180) of the Middle Eocene *Notharctus*, a primitive member of the Lemuroidea, has been briefly referred to by



Figs. 180 to 184. Skulls of Lemuroids. Subclass Placentalia, order Primates, suborder Lemuroidea, series Lemuriformes.

180. *Notharctus osborni*. Family Adapidæ, subfamily Notharctinæ. Middle Eocene, Lower Bridger, Orohippus zone, Bridger basin, Wyoming.
 181. *Adapis parisiensis* var. *bruni*. Family Adapidæ, subfamily Adapinæ. Upper Eocene, Phosphorites of Quercy, France. After Stehlin.
 182. *Adapis (Leptadapis) magnus*. Family Adapidæ, subfamily Adapinæ. Upper Eocene, Phosphorites of Quercy, France. After Stehlin.
 182a. *Adapis (Leptadapis) magnus*. After Stehlin.
 183. *Megaladapis grandidieri*. Family Lemuridæ, subfamily Megaladapinæ. Recent, Madagascar. After Standing.
 184. *Lemur mongoz*. Family Lemuridæ, subfamily Lemurinæ. Recent, Madagascar.

Dr. Wortman (1903, pp. 172, 174) and has recently been described and figured by the writer (1920, p.155). From imperfect skulls of the ancestral *Pelycodus* it seems probable that this type of lacrymal region even extended back into the Lower Eocene.

As compared with the lacrymal of more primitive Eocene placentals, that of *Notharctus* is characterized by the reduction of the pars facialis and the anomalous position of the lacrymal foramen, which lies in front of the lacrymal at the junction of the lacrymal, maxilla, and jugal.

Immediately below the frontal the lacrymal bears a prominent tuberosity, which doubtless served for the attachment of the palpebral ligament. Above the lacrymal and below and in front of the dorsal rim of the orbit there was a shallow groove on the frontal; a similar groove occurs in *Adapis* and in modern lemurs; it may have been the anterior insertion area of the sheet-like orbito-auricularis muscles. The proximal end of the nasals spread widely beneath the overlapping maxillæ. The jugal came very close to or actually touched the lacrymal.

Accordingly, the lacrymal region of *Notharctus* was essentially identical with that of *Adapis*, namely: pars facialis reduced or wanting, antorbital rim represented chiefly by a tuberosity, lacrymal foramen forming a fissure in front of the lacrymal at the junction of the maxilla, lacrymal, and jugal.

The lacrymal region of *Adapis parisiensis* was carefully described by Dr. Forsyth Major in 1901. Dr. Stehlin (1912, pp. 1196-1198, 1251, 1252) has confirmed and extended Major's account and has also described the lacrymal region of *Adapis (Leptadapis) magnus*. In comparison with other Eocene placentals, the three most striking features of the lacrymal in *Adapis* are, first, its small size; second, the preorbital position of the lacrymal foramen, which is a mere fissure in front of the lacrymal and between the lacrymal and maxilla; and, third, the virtual absence of a pars facialis, so that the lacrymal lies almost entirely within the orbit. The dorsal part of the pars facialis, immediately below the frontal, bears a tuberosity which is variously developed in different skulls. This is apparently homologous with the "crista posterior" of the lacrymal of modern lemurs and probably represents a remnant of the primitive antorbital rim. The jugal was sometimes in contact with the lacrymal (Stehlin, 1912, pp. 1251), sometimes separated from it by a narrow strip of the maxilla (Major, 1901, p. 135).

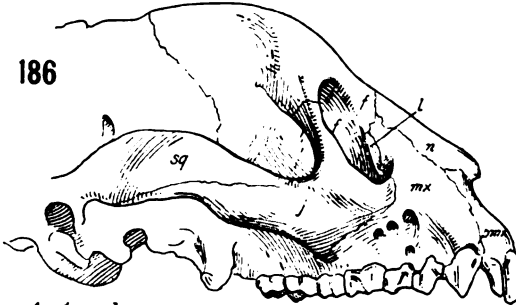
In a young skull of *Megaladapis grandidieri* (Fig. 183) described by Dr. Standing (1908), the jugal is shown in contact with the lacrymal and the lacrymal foramen is marginal, not preorbital. In adult specimens of

all three species of *Megaladapis* the lacrymal foramen is continuous with a large notch in the anterior border of the orbit, recalling the notch between the tuberosity and the lower border of the orbit in *Adapis*. The pars

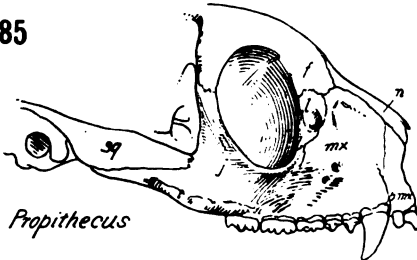
187

*Daubentonia (Chiromys)*

186

*Archaeolemur*

185

*Propithecus*

Figs. 185 to 187. Skulls of Lemuroids (continued). Subclass Placentalia, order Primates, suborder Lemuroidea, series Lemuriformes.

185. *Propithecus coquerelli*. Family Indridae, subfamily Indridinae.

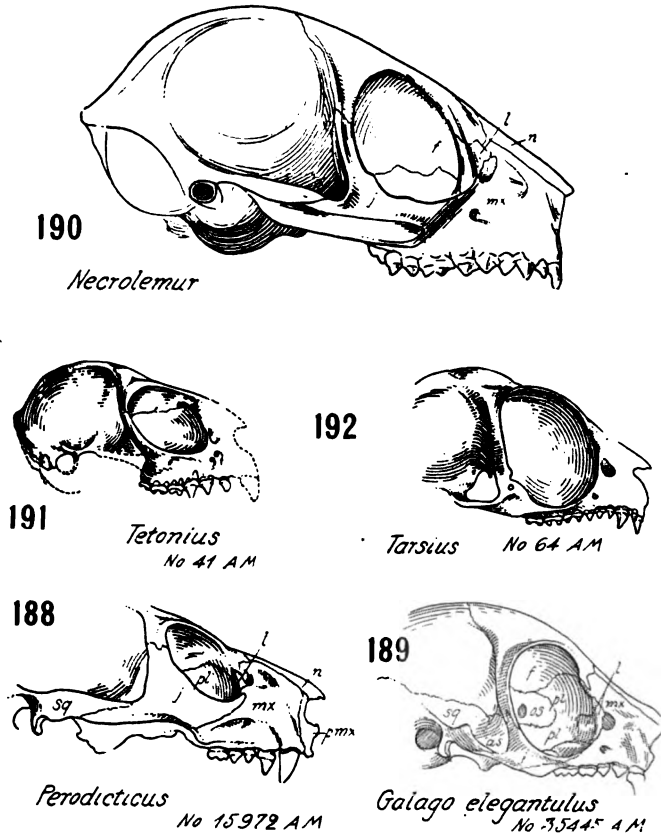
186. *Archaeolemur edwardi*. Family Indridae, subfamily Archaeolemurinae. Recent, Madagascar. After Standing. X 1.

187. *Chiromys* (= *Daubentonia*) *madagascariensis*. Family Chiromyidae.

facialis of *Adapis* seems to be much less extended anteriorly than it is in the modern *Lemur* (Fig. 184).

In *Lepilemur* (Amer. Mus. No. 31251), which is on the whole one of the most primitive of existing lemurs, the pars facialis is moderately

developed, the crista posterior and its tuberosity are prominent and the lacrymal foramen appears as a fissure between the lacrymal bone and the notched maxilla. Essentially similar conditions recur in other genera



Figs. 188 to 192. Skulls of Loriform Lemuroids, and Tarsioids. Subclass Placentalia, order Primates, suborders Lemuroidea, Tarsioida.

188. *Perodicticus potto*. Series Loriformes, family Lorisidæ, (Nycticebidæ), subfamily Lorisinæ.
 189. *Galago elegantulus*. Series Loriformes, family Lorisidæ, subfamily Galaginæ.
 190. *Necrolemur antiquus*. Family Necrolemuridæ. Middle (?) Eocene? Phosphorites of Quercy, France. After Stehlin. $\times \frac{1}{2}$.
 191. *Tetonius* ("Anaptomorphus") *homunculus*. Family Tarsiidæ. Lower Eocene, Coryphodon zone, Gray Bull beds, Bighorn basin, Wyoming. After Matthew. $\times 1$.
 192. *Tarsius spectrum*. Family Tarsiidæ. Recent, Borneo. $\times 1$.

of modern Lemuridæ, the most variable features being the extent of the pars facialis, which is short in the short-faced *Hapalemur* (*Mioixicebus*) and exceptionally large in adult *Lemur*. In the specimen of *Mioixicebus caniceps* figured by Elliot (1912, I, Pl. xiv) the lacrymal foramen is

represented by a long anteroposterior fissure on the side of the face, corresponding to the direction of the lacrymal canal.

Among the Indrisidæ, *Propithecus* (Fig. 185) has a lacrymal which is fundamentally similar to that of *Notharctus* except that the pars facialis is larger as well as the lacrymal canal and foramen. *Mesopropithecus* (Standing, *op. cit.*, Pl. xxii) and *Indris* (Milne Edwards, Pl. xxxiii) show only minor variations of the same type, while in *Lichanotus* (*Avahis* Milne Edwards, Pl. xlv, Major, Text fig. 43), in accordance with the secondary abbreviation of the muzzle, the pars facialis is very short and the foramen is marginal rather than preorbital in position.

As *Palæopropithecus* is clearly a degenerate relative of *Indris*, it is not surprising to find its lacrymal region (Standing, Pls. xi, xii) in the main similar to that of the last-named genus, save that the lower orbital rim (crista anterior) formed by the maxilla is more prominent and projects farther forward and that the foramen in one sense is not preorbital in position, although it is in front of the lacrymal bone.

In *Archæolemur* (Fig. 186) the lacrymal recalls that of *Adapis* and is comparatively primitive. In *Chiromys* (Fig. 187) the enlargement and rodent-like form of the incisors has stimulated an upward and backward growth of the premaxilla, which gains contact with the frontal and even with the lacrymal, crowding the ascending process of the maxilla into a narrow strip and widely separating it from the frontal. But in other respects the lacrymal of this animal is essentially similar to that of *Propithecus* (Fig. 185).

Among the more primitive of the loriform lemuroids (Figs. 188, 189) the lacrymal is essentially similar to that of *Adapis* save that the lacrymal foramen is larger and that the lacrymal itself is usually separated from the jugal by the maxilla. Apparently the jugal has retreated from its primitive contact with the lacrymal while its postorbital branch becomes relatively large. Further enlargement of the eyes merely emphasizes these conditions, as in the smaller Galaginæ (*Hemigalago*, *Galago elegantulus*).

In *Loris* and *Nycticebus*, as observed by Forsyth Major (1901, pp. 140-141), the lacrymal is vestigial or wanting, its place on the inner wall of the orbit being more or less usurped by an element which was identified by Major as the "os planum" or lateral exposure of the ethmoid.¹ The lacrymal foramen in all the Lorisidæ is well developed and is preorbital in position.

¹The observations of Dr. Wood Jones, (1917, Proc. Zool. Soc. London, pp. 323-329) show that the so-called os planum in *Lemur catta* is more probably the anterior plate of the palatine and that it is extremely difficult or impossible to distinguish the sutures on the medial wall of the orbit in many adult lemuroids.

The lacrymal region of *Necrolemur* (Fig. 190) has been described and figured by Stehlin (1916, pp. 1343, 1344) and is well shown in a specimen kindly loaned to the writer by the curators of the Museum of Comparative Zoology at Cambridge, Mass. The lacrymal forms a prominent rim on the anterior border of the enlarged orbit, and has a small pars facialis; the foramen, as in the loriform lemuroids, is preorbital in position. Stehlin says that the lacrymal as a whole recalls that of *Opoilemur* (*Atililemur*) *thomasi*, one of the Lemuridæ. In this animal the lower end of the lacrymal touches or nearly touches the jugal and the same may be true of *Necrolemur*. The ascending process of the maxilla bears the usual fossa for the insertion of part of the orbicularis palpebrarum muscle (Stehlin, 1916, p. 1345).

In the Lower Eocene tarsioid *Tetonius* (*Anaptomorphus*) *homunculus* (Fig. 191) the small lacrymal bears a prominent vertical ridge (crista posterior) on the anterior rim of the orbit. To this ridge was doubtless attached the palpebral ligament. In front of the ridge was a depression which may have marked the attachment of the orbicularis palpebrarum muscle. The lacrymal foramen was very probably preorbital in position as it is in *Tarsius* and *Necrolemur*. The lacrymal is widely separated from the jugal by the maxillary which forms the greater part of the rim of the orbit anteriorly.

The morphological significance of the above described conditions of the lacrymal region of the lower primates has been interpreted quite differently by Forsyth Major (1901, pp. 150-152) and Wortman (1903, pp. 406). Dr. Forsyth Major's interpretation of the evidence was as follows:

As to the Prosimiæ, if in the future we come upon forms in the Middle or Lower Tertiaries exhibiting a facial expansion of the lacrymal, and a facial fossa l., it will then be the time to ventilate the question whether a similar condition might after all be the primitive one in the Prosimiæ. For the present we have to reckon only with the known facts. In *Adapis parisiensis* we have found the fossa lacrymalis as well as the whole bone to be inside the orbit; the lacrymal is fairly large. From this condition, the form of the lacrymal of recent Lemurs generally can have been arrived at by the development of a crista posterior; that of the non-Malagasy Lemurs, besides, by a gradual reduction of the lacrymal; that of the Malagasy Lemurs, on the contrary, by an increase in size of the pars facialis. The large expansion of the lacrymal on the face and the anterior bordering of the canalis by the latter bone, both characters which among the Prosimiæ occur only in the Malagasy Lemurs, are rather an exception within this group; they go hand in hand with the elongation of the facial cranium generally. As a rule in the Malagasy Lemurs the pars facialis is of moderate size, and the anterior boundary of the fossa is provided by the maxilla. In the Oriental and Ethiopian Lemurs the maxilla *always* borders the fossa to a large extent and chiefly in front; the pars facialis is reduced to a minimum; the pars orbitalis is also

reduced, owing chiefly to the encroachment of the planum. In two genera (*Loris*, *Nycticebus*) the lacrymal disappears entirely from the outer side of the cranium, outside and inside the orbit.

Summing up, and in order to arrive at a generalization, the following points are to be insisted upon:—

A great facial expansion of the lacrymal, and particularly its extension beyond the fossa lacrymalis,—

1. Does not occur, the converse being the case, in the one Tertiary Lemur of which the lacrymal region is known;
2. It is scarcely more frequent in Lemurs than in the higher groups; the greatest reduction of the lacrymal occurs precisely within the Prosimiæ;
3. It is at its minimum in young individuals;
4. The genera of each group in which this character is presented have certainly no closer relationship with those of another group;
5. It can always be traced back to an elongation of the facial cranium, necessitated by a more powerful dentition.

The conclusion is that a great facial expansion of the lacrymal, and particularly its extension beyond the fossa lacrymalis is, in the Lemurs, as well as in the Monkeys, not a primitive condition, but an extreme specialization.

With these conclusions those of the present writer would very largely coincide, especially since the discovery of the lacrymal region of the Middle Eocene *Notharctus* (which in the vast majority of its skeletal characters is in a primitive lemuroid stage of evolution) materially strengthens Dr. Forsyth Major's view that the conditions of the lacrymal region of *Adapis* are essentially ancestral to those in modern lemurs. It is, however, apparently not necessary to assume with Dr. Major that the crista posterior of the lacrymal of modern lemurs represents a new development; to the writer it appears to be merely a remnant of the lacrymal part of the primitive antorbital rim, which has become separated from the lower part of the rim (crista anterior).

Dr. J. L. Wortman (1903, p. 406), citing Dr. Forsyth Major's studies, states that:

From his (Major's) investigations we learn that, with the single exception of *Nesopithecus*, a highly developed extinct type from Madagascar, all the lemurs possess an enlarged lachrymal which reaches beyond the orbit, while the external opening of the lacrymal canal is situated upon the side of the face.

In connection with this passage Dr. Worthman says on page 407:

The large lachrymal with the opening of the canal extraorbital in position is undoubtedly the primitive condition. This is demonstrated by reference to the Marsupials, in some of which, notably *Myrmecobius*, it is unusually large and sends a considerable spur outward upon the zygoma to join the malar. In all Insectivora, Rodentia and primitive Carnivora, the enlarged lachrymal as well as the extraorbital position of the canal is so far as I am aware universal.

The writer, on the contrary, finds it impossible to accept these statements and this conclusion and is, therefore, moved to make the following comments.

1. The condition of the lacrymal region in recent marsupials assuredly does not "demonstrate" that the "large lachrymal with the opening of the canal extraorbital in position" is the primitive condition for lemurs, which are specialized placental mammals very widely removed from the existing marsupials.

2. The conditions in *Myrmecobius* seem, to the writer, obviously not primitive as compared with the conditions in most other polyprotodont marsupials (see page 143 above).

3. The position of the lacrymal foramen in marsupials is essentially different from the "extraorbital position" of this foramen in modern lemurs, since in the former case the foramen, or at least one of the lacrymal foramina, is either behind the antorbital rim or is marginal, while in lemurs it is typically in front of the lacrymal bone, forming a groove or fissure between it and the maxilla.

4. All Insectivora, Rodentia and primitive Carnivora assuredly do not have either the enlarged lacrymal or the extraorbital position of the canal (=posterior opening of the canal?). The facts are indeed quite different. Eocene Carnivora show the pars facialis in various degrees of development. It appears to be only moderately developed in the very primitive *Deltatherium* and widely extended on the face in the relatively highly specialized Mesonychidae and Hyænodontidae. The lacrymal foramen in primitive carnivores, so far as the writer has been able to observe, is behind the antorbital rim and never in front of the lacrymal bone, between the lacrymal and the maxilla, as it is in typical lemurs.

The adult erinaceoid insectivores, from the Oligocene onward, have little if any pars facialis and the foramen is marginal. According to W. K. Parker's figures of *Erinaceus* embryos and young (1885, Pls. xvii-xx), the lacrymal foramen in the young stages is behind the crista anterior of the maxilla and therefore fully within the orbit. In the young *Talpa* (Pl. xxvi) and *Sorex* (Pl. xxxi), on the other hand, the foramen is definitely preorbital and (*Talpa*) in front of the lacrymal. In the primitive zalambdodont *Nesophontes* the foramen is marginal; in the specialized *Centetes* and *Solenodon*, on the other hand, the foramen comes to lie in front of the lacrymal. And none of these have a true pars facialis, that portion of the orbit which remains being undoubtedly the pars orbitalis. In the primitive Eocene rodents of the family Ischyromyidae

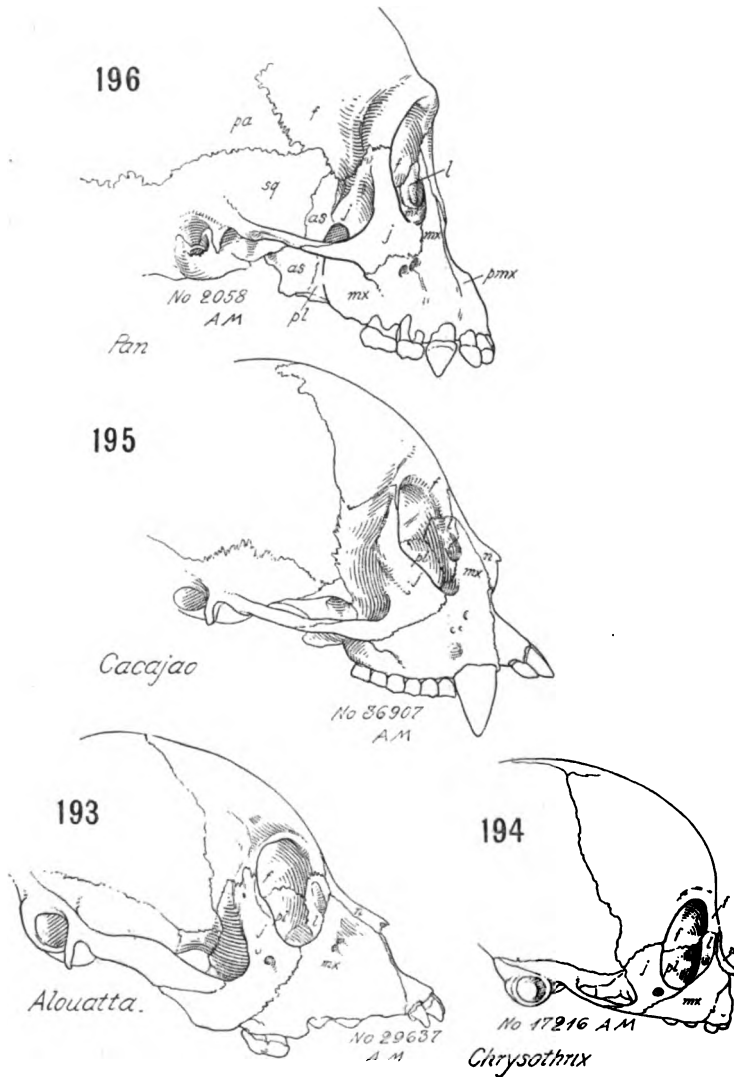
the *pars facialis* of the lacrymal is small and the foramen is marginal or behind the antorbital rim.

5. In the most primitive Condylarthra, Amblypoda, Rodentia, Tæniodonta, Artiodactyla, Perissodactyla, Menotyphla, etc., the lacrymal foramen is behind the antorbital rim, while in many other placental mammals it is marginal, but it is only in forms which the writer regards as specialized that the foramen shifts forward along the lacrymal duct to a position in front of the lacrymal.

6. As already noted by Forsyth Major, the extent of the *pars facialis* is variable in recent lemurs, attaining the maximum in adult specimens of the genus *Lemur* and being much less in young specimens and in all the Indrisidæ and Nycticebidæ. Hence it seems reasonable to infer that the extended *pars facialis*, when it does occur, is a secondary character, the more so as this character is the opposite of what is known in the Eocene lemuroids *Adapis* and *Notharctus*.

Up to the present time apparently no one has attempted to discover the functional significance either of the extended *pars facialis* of *Lemur* or of the extreme anterior position of the lacrymal foramen in all the Lemuroidea and Tarsioidæ. As to the first character, cross-sections of the skull of *Lemur varius* show that the whole nasal cavity (which is of itself unusually large as compared with that of higher primates) is surrounded by a system of greatly inflated sinuses which communicate with the antrum and which have already been noticed in other connections by Forsyth Major (1901, pp. 26). These sinuses are covered externally partly by the lacrymal bone, of which both the *pars orbitalis* and the *pars facialis* are in consequence excessively large. Similar but smaller sinuses are present in other Lemuridæ and Indrisidæ. But in the loriform Lemuroidea, and still more in *Tarsius*, the marked reduction of the nasal cavity, and the crowding together of the orbits toward the midline, are associated both with a reduced lacrymal and a reduced system of sinuses. Somewhat parallel conditions may be observed in marsupials, the excessively large lacrymal of *Myrmecobius* being associated with an equal development of the lacrymal sinus.

The apparent explanation of the anterior position of the lacrymal duct has been gained by dissection of the orbital region of an ordinary *Lemur*. It was then seen that the eyes bulge from their sockets, that the inner canthus of the eye is carried far forward and with it the lacrymal foramen. This condition becomes very pronounced in the smaller Nycticebidæ and still more in *Tarsius*. From the forward position of the lacrymal foramen in *Notharctus* and *Adapis* as compared with other



Figs. 193 to 196. Skulls of apes and monkeys. Subclass Placentalia, order Primates, suborder Anthropeidea.

193. *Alouatta (Myces) beelzebub*. Series Platyrrhinæ, family Cebidæ. Young skull, pl, os planum.
 194. *Chrysothrix* sp. Series Platyrrhinæ, family Cebidæ. Young skull.
 195. *Cacajao calvus*. Series Platyrrhinæ, family Cebidæ.
 196. *Troglodytes (=Pan)* sp. Series Catarrhinæ, family Simiidae.

Eocene placentals, it is legitimate to infer that even in these early primates the protrusion of the eyes and the forward shifting of the inner canthus of the eye had already begun. That their eyes were of lemuroid type is also indicated by the whole conformation of the orbital region.

With relatively minor variations and irregularities (described by Major), a single type of lacrymal runs through all the *Platyrrhinæ* (Figs. 193-195) and *Catarrhinæ* from *Mycetes* (*Alouatta*, Fig. 193) to the higher apes (Fig. 196) and to man.

This fundamental unity of type is connected with the forward direction of the orbits, with the great increase in depth of the frontal region and with the narrowing and retraction of the muzzle, these changes being in turn partly correlated with the forward growth of the frontal region of the brain and with the change in the normal position of the head on the backbone, connected primarily with sitting and brachiating habits.

Typically, the lacrymal is a small and vertically extended bone appressed to the inner wall of the orbit and having little or no pars facialis. The lacrymal foramen, or fossa, is typically in front of the lacrymal and between the lacrymal and maxilla, but in some cases, (baboons, adult *Mycetes*) in connection with the secondary elongating of the face, the lacrymal foramen is displaced backward so as to pierce the lacrymal bone, the rule being that the position of the foramen is governed in part by the position of the inner canthus of the eye and by the inclination of the lacrymal duct, which, in turn, is correlated with the depth and length of the face.

Among the *Platyrrhinæ*, the variable development of maxilla, lacrymal, and frontal often brings about a retreat of the maxilla from the frontal, a loss of the fronto-nasal contact, and the establishment of a nasol-acrymal contact; but in many other cases observed by Dr. Forsyth Major (1901, pp. 143-147) the maxillo-frontal contact is retained. The precise position and limits of the lacrymal fossa are usually quite variable. The lacrymal itself varies widely in size, being sometimes very small (*Midas*), sometimes fairly large (adult *Mycetes*), this depending in part on the size of the muzzle. So much of the jugal is devoted to the formation of the postorbital rim and partition that the jugal is widely separated from the lacrymal, leaving the maxilla to form the crista anterior of the orbit. On the inner wall of the orbit the lacrymal (Fig. 193) is in wide contact with the os planum (*pl*) of the ethmoid, as in most of the higher primates.

In the catarrhine division of the Anthropoidea (which division is here understood as including the Old World monkeys, anthropoids and man) the maxilla usually retains its contact with the frontal in spite of the deepening of the face, so that a naso-lacrymal contact is very exceptional. The lacrymal is essentially of the human type with only minor and variable differences. Usually the lacrymal groove or fossa is between the lacrymal and maxilla but in some cases, especially in connection with the secondary elongation of the face in some baboons (Major, Pl. xi, fig. 9), the foramen may be entirely surrounded by the lacrymal. In the gibbon, orang, some chimpanzees, and man the lacrymal is normally in wide contact with the os planum of the ethmoid, but sometimes this contact is replaced by a contact between the orbital walls of the frontal and of the superior maxilla, the latter being thrust up between the lacrymal and the os planum. This is said to be the normal disposition in the gorilla and chimpanzee (Cunningham, 1903, p. 134), and occurs as a variant in man.

Taken in connection with the fundamental unity of construction of the auditory region and indeed of the whole skull throughout the Platyrrhinæ and Catarrhinæ, the lacrymal region offers additional evidence for the traditional view that the suborder Anthropoidea is a natural group. In both the Platyrrhinæ and the Catarrhinæ the retreat of the lacrymal within the orbit is carried to its logical extreme along with the extreme forward turning of the eyes and the consequent inward shifting of the inner canthus of the eyes. From this line of development *Tarsius* and all the modernized lemurs are definitely ruled out through the forward shifting of the lacrymal correlated with bulging eyes directing partly outward; but the lacrymal region of the primitive lemuriform *Notharctus*, as Dr. Wortman well observes (*op. cit.*, p. 410), could readily give rise to that of the Platyrrhinæ and thus to that of all higher primates.

SUMMARY OF THE EVOLUTION OF THE LACRYMAL BONE

The present study, in the writer's judgment, lends strong support to the so-called "Cuvierian concept": namely, that the lacrymal of mammals is the homologue of the lacrymal of the Crocodilia, as named by most authors up to the time of Gaupp and Jaekel, who, on the contrary, held that the Cuvierian concept was erroneous and that the lacrymal of mammals had been derived from the so-called prefrontal of reptiles.¹

Arising as a derm bone, one of the circumorbital series in the rhipidistian fishes, the lacrymal has primary contacts with the prefrontal,

¹ See also Addendum, p. 263.

the jugal, and possibly with the parethmoid, or lateral ossific center of the olfactory capsule, as well as with the palatine. The lacrymal in primitive fish is traversed by the suborbital branch of the lateral line canal; according to Watson this duct may well have given rise to the naso-lacrymal duct, an epithelial derivative with which the lacrymal bone is always typically associated.

In the earliest Tetrapoda the circumorbital series of bones are becoming better differentiated from each other and, in the oldest reptiles, the jugal and squamosal show the beginning of the zygomatic arch. The appearance of the temporal fossa in the early synapsid reptiles was also a significant stage.

As we pass from the lower to the higher classes of vertebrates and from the more primitive to the more specialized members of each class, we observe in general a marked reduction in the number of derm bones covering the skull and attached structures. Thus the teleostomous fishes have by far the highest number. The earliest Amphibia have already lost all the bones of the opercular series, while the modern Amphibia usually have an impoverished skull, lacking the postfrontal,¹ the intertemporal, the supratemporal, postorbital, dermosupraoccipital, tabular, and other elements. The birds lose, among others, the elements of the upper temporal arch, while the mammals sacrifice the pre- and postfrontals, postorbitals, intertemporals, supratemporals, tabulars, quadratojugals, and several elements of the lower jaw. The lacrymal bone often shares the fate of these other elements, especially in many modern Amphibia, and in Chelonia, Ophidia, Rhynchocephalia, and birds; in the last three groups the place of the lacrymal is usurped by the prefrontal. So, too, among the mammals the more primitive types always retain the lacrymal, while in degenerate or highly specialized skulls it is often reduced (e.g., *Ælurus*, many Ursidæ, certain Viverridæ and Mustelidæ) and is sometimes lacking (Monotremes, *Manis*, Phocidæ).

As the orbit was doubtless originally near the anterior end of the head, the lacrymal at first extended from the orbit to the nares, and there it has been found in many of the most ancient and primitive types of Amphibia and reptiles.

In early reptiles the progressive upgrowth of the maxilla covers the anterior part of the lacrymal and is associated with the loss of the lacrymal-parethmoid contact and with the establishment of a lacrymal-

¹This element is doubtfully recorded in some of the Salamandridæ.

maxillary contact. The lacrymal from the first has contact with the spreading nasal and with the jugal. In this stage, which is represented in the Pelycosauria and Therapsida, the lacrymal is pierced by the naso-lacrymal duct, the foramen opening just in front of the orbit, the duct passing downward and forward to open into the nasal cavity.

In the Diapsida or Archosauria, the lacrymal is primitively a large element, often perforated or bordered by the antorbital fenestra, and serving as a brace between the upper jaw and the frontal region of the skull.

In the ancestral mammals the establishment of a dentary-squamosal contact and the forward growth of the temporal muscles conditioned the disruption of the postorbito-jugal contact, the disappearance of the postorbital, and perhaps the forward crowding of the frontal. The prefrontal also disappeared and the only parts of the primitive circum-orbital series remaining are the lacrymal and the jugal. The lacrymal of cynodonts gains contact with the nasal and retains its contact with the jugal. It is pierced by one or two foramina, which are probably connected with the naso-lacrymal duct.

By the loss of the prefrontal the lacrymal gains a wide contact with the frontal, which it never loses. This is the stage apparently represented in the Lower Jurassic mammal *Tritylodon*.

The contact of the lacrymal with the palatine, which we find in mammals, was established in many fishes and was thence transmitted to the Stegocephalia and higher vertebrates.

In cynodont reptiles, as well as in primitive mammals, the lacrymal transmits the strains from the zygomatic arch to the nasals, frontals, maxillæ, and palatines.

With the transformation of cold-blooded reptiles into warm-blooded mammals the stiff mask-like face of reptiles is changed into the mobile face of mammals, through the forward migration of the sphincter colli muscles and the differentiation into the muscles of the lips, cheek, and eyes (Ruge).

Part of the orbicularis muscles (preorbicularis dorsalis, ventralis) become attached to the facial part of the lacrymal and the "tarsal ligament" of the eyelids is attached to the lacrymal on the lacrymal tubercle. All this occurred perhaps during the second half of the Mesozoic Era and is known to us through internal morphological evidence rather than by direct palæontological material.

Among the mammals, the most primitive known types of lacrymal region are found among existing carnivorous marsupials and among such

Paleocene placentals as have more primitive types of dentition. In these forms the skull is macrosmatic, being long and low with a thick muzzle, very narrow brain-case, stout jaws and zygomatic arches, and more or less primitive tritubercular dentition. The eyes are of moderate size with very small postorbital processes. The prominent antorbital rim is formed by the frontals, lacrymals, and jugals, and the eyes are directed outward rather than forward. The dorso-anterior part of the antorbital rim protrudes laterally as seen from above. The lacrymal at this stage has a moderate pars facialis and the foramen is behind the antorbital rim, opening backward. It also has contacts with frontal, nasal, maxillary, jugal, and palatine. Its pars orbitalis covers the lateral extension of the ethmoid scrolls. Its small pars facialis serves for the attachment of the orbicularis, preorbicularis dorsalis and p. ventralis muscles, and its tubercle for the ligament of the palpebral cartilages and, at least sometimes, for the deep fascia of the frontal region.

In general, the marsupials have a more extended dorso-anterior rim on the lacrymal than have the primitive Paleocene placentals and some of them retain the naso-lacrymal contact which in the most primitive placentals was early replaced by a fronto-maxillary contact. Perhaps the most primitive known examples of this stage are *Amphiprovierra* among the marsupials and *Deltatherium* among the Paleocene placentals.

Such animals, although macrosmatic, have a well-balanced condition of the olfactory and visual organs in harmony with their primitively carnivorous or semi-carnivorous habits. But even long before the Paleocene epoch various lines of specialization were initiated which eventually resulted in wide differences in food habits, dentition, sense organs, locomotor organs, etc., so that by Paleocene times we find many specialized placental types such as *Psittacotherium*, *Nothodectes*, *Palæanodon*. Fortunately, however, the "persistent primitive types" of Paleocene and later times such as *Deltatherium*, *Onychodectes*, *Hyopsodus*, *Miocænus*, and many others give us a better idea of what the more generalized Mesozoic precursors of the placental orders were like.

Specialization in food habits, etc., has affected the lacrymal region of mammals in several ways.

(1) Excessive increase in the olfactory scrolls of the ethmoid region and concomitant widening of the frontal region may accompany more or less inflation of the lacrymal region or of the sinuses surrounding the nasal chamber, as in *Myrmecobius*, *Tupaia*, *Galeopithecus*, *Lemur*, and many ungulates.

(2) On the other hand, a great decrease in the olfactory region may condition the dwindling in size of the lacrymal, as in the microsmatic *Lorisidæ* and *Tarsiidæ*.

(3) A dorsad displacement of the orbital root of the zygomatic arch through excessive development of the anterior part of the masseter may crowd the lacrymal dorsad and cause its reduction in size, as in *Phascolumys*, rodents, and typotheres.

(4) A backward and upward growth of the nasal tract and surrounding muscles, causing the backward and upward growth of the maxillary, may crowd back the lacrymal and reduce its *pars facialis* as in the tapir and the elephant.

(5) The encroachment of the maxillary upon the zygomatic arch may separate the lacrymal from the jugal, as in *Erinaceus*.

(6) The encroachment of the maxillary upon the vertical plate of the palatine may separate the lacrymal from the palatine, as in many insectivores.

(7) The development of horns or bony apophyses either in the orbital or in the nasal regions affects the lacrymal in various ways. In the later titanotheres the lacrymal contributes to the bony pillar that supports the "horns" laterally. In the African rhinoceroses the growth of the nasal horns has perhaps conditioned the forward growth of the nasals and their withdrawal from the naso-lacrymal contact. In the *Bovidæ* the greatly enlarged *pars facialis* of the lacrymal contributes largely to the strengthening of the face below the horns.

(8) A backward displacement of the orbit, correlated with the forward prolongation of the snout, may condition the elongation of the *pars facialis* of the lacrymal, as in *Orycteropus*, *Megalohyrax*, *Phaco-chærus*, and many artiodactyls.

(9) An extreme forward displacement of the orbit may condition the elongation of the orbital wall of the lacrymal, as in *Manatus*.

(10) Extreme enlargement and protrusion of the eyes may crowd the lacrymal almost entirely out of the orbit, its place being taken either by the *os planum* of the ethmoid or by the palatine, as in the *Lorisidæ* and *Tarsiidæ*. In such cases the lacrymal foramen is crowded out of the orbit and is located between the lacrymal and the maxilla.

(11) On the other hand, a marked reduction of the eyes causes the subsidence of the antorbital rim, the loss of the lacrymal tubercle, and the close appression of the orbital wall of the lacrymal to the side of the frontal, as in *Myrmecophaga*, zalambdodont insectivores, moles, shrews, etc.

(12) Finally, when the direction of the eyes is shifted, so that they point forward rather than outward, and when, at the same time, the olfactory region is reduced, we have a more or less complete withdrawal of the lacrymal into the orbit, as in all the higher monkeys, apes, and man.

In general, it may be said that the loss of one or more of its primitive contacts tends to release the lacrymal from its hereditary conditions and restrictions and to that extent frees it for new lines of either specialization or reduction.

In some cases it would appear that the lacrymal is not altogether a passive object, which is pushed and moulded by its surroundings, but that it has, so to speak, a certain inherent tendency either to increase, as in the excessively large lacrymal of many artiodactyls, or to diminish, as in the lacrymal of many fissiped Carnivora.

In conclusion, the form and size of the lacrymals of mammals are conditioned, first, by intrinsic hereditary factors which cause the lacrymal to increase or to diminish and, secondly, by several external factors such as the position of the orbits, the length of the snout, the width of the ethmoid region, the degree of inflation of the sinuses around the nasal cavity, special developments of the maxillary and jugal, and diverse modifications of the eyes and circumorbital muscles. In a general way, anteriorly placed orbits, short snouts, and a narrow ethmoid region are found in connection with small lacrymals, with reduced facial exposure, and vice versa, but each case is complicated by special conditions.

THE LACRYMAL PROBLEM IN ITS PHYLETIC AND TAXONOMIC ASPECTS: A PHYLOGENETIC REVIEW OF THE VERTEBRATES

The elements of the lacrymal complex being relatively few in number, it is not surprising to find more or less similar combinations sometimes occurring independently in widely different groups, so that in such cases a similarity in the pattern of the lacrymal region does not denote near relationship. A case in point is the superficial resemblance of the orbital and lacrymal region of the specialized cotylosaurian genus *Procolophon* to those of certain lizards, and another is the general similarity of the whole face, including the lacrymal, of *Myrmecobius*, a marsupial, *Rhynchocyon*, a menotyphlous insectivore, and *Homacodon*, an artiodactyl. Under the category of homoplastic resemblances belong also many of the cases with an extended pars facialis of the lacrymal, such as the following:

<i>Thylacinus</i>	<i>Hyænodon</i>
(Order Marsupialia)	(Order Carnivora)
<i>Orycteropus</i>	<i>Myrmecophaga</i>
(Order Tubulidentata)	(Order Edentata)
<i>Megalohyrax</i>	<i>Phacochærus</i>
(Order Hyracoidea)	(Order Artiodactyla)

On the other hand, the lacrymal region usually bears so peculiar and characteristic a stamp in a series of genera, or even in larger groups, that there can be little doubt of its inheritance from a common ancestor. Good examples of this class are the unity of general type of the lacrymal region throughout the suborder Anthropeidea, the characteristic patterns of the lacrymal in Eocene perissodactyls, artiodactyls, and many other groups.

In fact, when the more detailed patterns of the whole circumorbital region of any two given examples are carefully compared, especially when the functional significance of the given configuration is appreciated, the deceptive resemblances due to convergence or homoplasy are easily recognized and characters of diagnostic value will often be discovered. On the other hand, a classification and a phylogenetic tree of the vertebrates, if based on the characters of the lacrymal region alone, could hardly be expected to yield uniformly reliable results, because at the present time it is generally realized that the whole is greater than any of its parts and that, in order to be durable, a phylogenetic diagram must be based upon as many sources of evidence as possible. Studies by many investigators on special parts and systems, such as the auditory region, the dentition, and the limb structure, together with the far more numerous systematic studies of zoologists and palæontologists, have already provided a general background of knowledge concerning the interrelationships and classification of the vertebrates, so that the attempt may now be made to integrate with the general results already attained from other sources such systematic and phylogenetic evidence as our study of the lacrymal region has yielded.

Dipnoi

The ring of large plates around the eye of Paleozoic dipnoans seems to be, on the whole, homologous with the circumorbital ring of contemporary Crossopterygii, since in both groups this series often bears a more or less complete circumorbital branch of the lateral line canal. This fact, taken in connection with other evidence, points to a common origin of the two great groups, although in view of the form differences

of these elements, both as between the larger groups and as between different genera of the same group, there may be some doubt as to the homology of particular elements in certain cases. In any event, the patterns of the circumorbital series of Devonian Dipnoi and Crossopterygii are sufficiently different to indicate a long pre-Devonian period of divergence of these two stocks from a common ancestral stage.

The circumorbital elements of Arthrodira do not, to the writer, have the appearance of being homologous with those of Dipnoi or of other true fish, from which they differ widely in number and form.

Crossopterygii

The typical Palæozoic crossopterygians have four large circumorbital plates, including the prefrontal, lacrymal, jugal, and postorbital. The so-called supraorbital looks like a true prefrontal, while the "prefrontal" of Watson and Day (1915) appears to be homologous with that bone in *Amia* which was named "antorbital" by Sagemehl and Allis and "preorbital" by Bridges. This dermal preorbital element of *Osteolepis* seems to be homologous with the so-called "anterior frontal"¹ (Traquair, Wellburn) of *Megalichthys* and *Eusthenopteron*. Apparently the most primitive circumorbital pattern in this order is that of *Osteolepis*, from which may have been derived, on the one hand, that of *Glyptopomus* and eventually of *Holoptychius* and, on the other hand, those of *Rhizodopsis* and *Eusthenopteron*.

The coelacanths (order Actinistia) show the preorbital and "supraorbital" (=prefrontal) broken up into a long tract of squarish ossicles. The lacrymal is a triangular bone in the right position for that element, while the jugal is represented by the enlarged "suborbital" (see Goodrich, 1909, p. 288, Fig. 261). The postorbital remains in place.

Polypterus (of the order Cladistia), as would be expected in a modern survivor of the ancient Crossopterygii, exhibits a specialized and partly degenerate condition of the circumorbital region. Apparently both the dorsal (prefrontal) and the ventral (jugal) members of the circumorbital series have been lost and only the anterior (lacrymal) and posterior (?postorbital) members remain. The lacrymal is a wedge-shaped element that begins to simulate that of the Tetrapoda (see page 113 above).

Dr. Goodrich (1909, pp. 290-300) has cited numerous facts in support of his view that *Polypterus* is very widely removed from the true Crossopterygii and has perhaps a closer affinity with the Actinopterygii. In the present connection it may be said only that the Cladistia appear

¹Not to be confused with the true "anterior frontals" (prefrontals) of tetrapods (see page 97).

rather to be a degraded remnant of the coelacanth (Actinistia), which have lost many primitive crossopterygian characters and in many respects have become more completely ichthyized than their Palæozoic ancestors. The lacrymal region of *Polypterus* could readily be derived from that of the coelacanth chiefly through the loss of the preorbital and suborbital elements and the further specialization of the wedge-shaped lacrymal.

Actinopterygii

In the most primitive Chondrostei (Palæoniscidæ) the eye is enclosed in a narrow dermal ring which appears to be the homologue of the circumorbital series of other fish but is not subdivided into four or five elements. Behind and above this inner ring in primitive Palæoniscidæ is a second series ("postorbitals"), apparently homologous in part with the second ring of the higher ganoids. Behind this series again comes the preoperculum and expanded maxilla, while the true opercular series (operculum, subopercular, and branchiostegals) constitute a fourth and hindmost series. The Platysomidæ exhibit a closely allied pattern, differing in the reduction in number and enlargement of some of the elements of the second ring and in the shortening and deepening of the third and fourth rows. In the modern Spoonbill hardly a trace of this primitive pattern remains, but the sturgeons preserve more of it.

In the primitive Holostei (e. g., *Dapedius*, *Lepidotus*) the inner ring is of large size and well differentiated into from nine to twelve elements, of which two at the lower anterior border of the orbit have the position of the lacrymal. The second row is also subdivided into numerous pieces, behind which comes the preoperculum and next the opercular series. The pattern in *Lepidotus* could readily give rise to that in *Lepidosteus* (Fig. 4) through the elongation of the rostrum and the fragmentation of the maxilla, lacrymal, and other elements.

In *Amia* (Fig. 3) the lacrymal (*l*) and two of the posterior elements (*po*¹, *po*²) of the inner row have become greatly enlarged, the second row has disappeared, leaving the preoperculum more exposed, while the opercular series remains intact. From this amioid pattern that of the more primitive teleosts such as *Elops* has doubtless been derived.

Thus the pattern of the circumorbital region of primitive Actinopterygii affords some evidence for the following phylogenetic and systematic conclusions.

(1) The primitive Actinopterygii are only very remotely related to the primitive Crossopterygii; their respective circumorbital patterns

have probably been derived from an undifferentiated osteichthyan stage, possibly antedating the formation of definite joints in the skin covering the face.

(2) The primitive Chondrostei differ widely from the primitive Holostei in the circumorbital pattern as well as in many other characters, this being evidence of a very early separation of these groups.

(3) The circumorbital pattern of *Lepidosteus* is apparently more readily derived from that of *Lepidotus* than from that of *Eugnathus*, an inference which is in harmony with other evidence cited by Goodrich (pp. 335, 342-344).

(4) The teleosts are closely related to the amioids and show further advances in the specialization of the lacrymal as a large and prominent brace in front of the orbit. This character it retains in very many groups of teleosts, often in spite of high specialization in other parts of the face. This relatively primitive condition of the lacrymal is retained even in the more primitive of the Acanthopterygii, which are the highest of the teleosts. On the other hand, the lacrymal, like other elements, is subject to reduction and loss, especially in degraded families. Some of the other circumorbital bones occasionally afford diagnostic characters, such as the subocular shelf of primitive Acanthopterygii, the "pre-opercular stay" formed by the third suborbital of scorpenoids, etc.

Stegocephalia

The structural and phylogenetic gap between the Stegocephalia and the Crossopterygii, which are their nearest relatives among the fishes, is very great, far greater than that between the Stegocephalia and its contemporaries, the primitive Reptilia. Nevertheless, both these higher classes retain all the elements of the piscine circumorbital series, but so diversely modified in the very numerous and highly specialized families of temnospondyls, branchiosaurs, microsaur, cotylosaur, etc., that at first the pattern of the skull roof of Palæozoic Tetrapoda seems like a "shifting mosaic," in which now one and now another element becomes enlarged and pushes itself into new contacts, usurping the place of its diminishing neighbors.

Notwithstanding the labors of Miall, Cope, Fritsch, Moodie, and many others, the family classification of the Palæozoic Amphibia remains in a rather vague and unsatisfactory state,¹ so that it has seemed worth while to examine the patterns of the circumorbital region in the

¹This sentence and, indeed, this whole section on the Amphibia were written a year or more before I received from Dr. Watson a copy of his memoir on "The Evolution of the Amphibia, Part I". Abel's work on "Die Stämme der Wirbeltiere" was also received too late for me to consider his classification of the Amphibia and Reptilia in this paper.

numerous genera and supposed families in search not only of diagnostic characters but also of evidence concerning the phyletic interrelations of the larger groups.

Eventually this will have to be done by some one like my friend Dr. Watson, who, it is to be hoped, will make another tour of the principal museums of the world and narrowly examine the original material.¹ But the extensive literature of the subject, together with the material at hand, has tempted the writer once more to review the patterns of the skull top of Palæozoic Amphibia, as figured especially in the well-known works of von Meyer, Fritsch, Credner, Thévenin, Broili, Moodie, von Huene, Broom, Watson, and Williston. Owing to the great difficulty in correctly determining the sutural pattern in most specimens of early Tetrapoda, the published figures have been examined critically and with the doubts occasioned by the diverse results reported by different observers of the same or similar materials.

In general, the abundant materials and carefully executed figures published by von Meyer and by Credner seem to withstand the closest inspection and inspire confidence in the accuracy of the sutural limits and patterns as determined by these authors. On the other hand, a critical study of Fritsch's figures of the skull roof of *Branchiosaurus*, *Chelydosaurus*, and of some other types, has raised doubts as to their accuracy in certain particulars which will be noted presently. Williston's final figure of *Trimerorhachis* was based upon a large series of well-preserved specimens, studied with all the caution and intensity for which he was noted. They confirm in the main the figures by Broom, based on less satisfactory material.

In the appended tables are recorded fourteen characters of the lacrymal region, including the presence or absence of the lacrymal itself, and the presence or absence of certain sutural contacts between different elements in its vicinity.

Some of the phylogenetic and systematic conclusions which may be drawn from this study seem to be as follows.

(1) All the more primitive Tetrapoda are characterized by the presence of the lacrymal bone, which is in contact with the prefrontal, nasal, maxilla, jugal, and probably with the palatine.

(2) The early Temnospondyli retain the greatest number of presumably primitive amphibian characters, while the branchiosaurs and microsaurians are more or less aberrant or peculiar—perhaps in correlation with a shortening and broadening of the head.

¹ See footnote on preceding page.

(3) In most Temnospondyli the lacrymal is excluded from the orbit by a prefrontal-jugal contact and from the nares by a naso-maxillary contact. This may well have characterized the primitive temnospondyls, although in some cases the lacrymal retains its piscine location on the anterior border of the orbit.

(4) The numerous genera of rhachitomous temnospondyls which are here provisionally grouped under the family Archegosauridæ are distributed under several families by Fritsch, but show a substantial agreement in the pattern of the skull top as well as in the vertebræ.

(5) The Stereospondyli closely agree in the pattern of the lacrymal region with the Eryops group of the Temnospondyli, from which, as Watson has shown, they probably have been derived.

(6) The short-headed temnospondyls belong to two quite distinct families—the Brachyopidæ and the Dissorophidæ, characterized by differences in the lacrymal region and in development of the otic notch.

(7) *Micropholis* is aberrant in the vestigial condition of the jugal, as well as in other characters.

(8) *Trimerorhachis* is peculiar in the fact that the lacrymal excludes the jugal from the orbital border.

(9) *Chelydosaurus*, as restored by Fritsch, is characterized by the extreme extension of the jugal from the nasal to the squamosal, by the absence of the lacrymal and by the forward extension of the postorbital beneath the orbit so as to gain contact with the prefrontal. Fritsch's plates, however, do not carry conviction on these points.

(10) In Fritsch's figures of *Branchiosaurus* and *Dawsonia* the jugal is represented as extending forward beneath the orbit so as to gain contact with the nasals. But Credner's numerous figures of *Branchiosaurus* in all stages of development give no hint of such an extraordinary condition. Possibly Fritsch's "jugal" is merely the space between the superior maxilla and the bones below the orbit, which are the prefrontal and the jugal. In *Branchiosaurus* the lacrymal is absent even in very young specimens. In the much more primitive *Pelosaurus* the lacrymal is present and the pattern of the whole skull top is clearly allied to the primitive rhachitomous type.

(11) *Stegops*, if it is a microsauro, is apparently very primitive in the extension of the lacrymal from orbit to nares. Its isolated position is noted by Dr. Moodie (1916, p. 112).

(12) *Acanthostoma*, although known from well-preserved skulls figured by Credner, is difficult to place. It resembles *Dasyceps* and *Salamandrina* in the presence of a large intermaxillary fossa. Its lacrymal region is primitive.

(13) Among the microsaur, as figured, the lacrymal is often absent, the prefrontal frequently usurping its place; but when the lacrymal is present the pattern of this region recalls that of the Temnospondyli.

(14) The modern Anura, being degraded and specialized forms, have sacrificed most of the elements of the lacrymal region and seldom retain even doubtful vestiges of the lacrymal itself. But the whole skull pattern of the Anura is reminiscent of the short-faced Rhachitomi¹ rather than of the branchiosaurs, which, as Dr. Moodie has suggested, may well be ancestral to *Cryptobranchus* and its allies.

(15) Notwithstanding the loss of many other skull elements, certain amblystomid salamanders retain a primitive preorbital region, including a well-developed prefrontal and a small lacrymal, pierced by a naso-lacrymal duct (see page 117). Derivation from the conditions seen in *Pelosaurus* and the primitive temnospondyls seems possible.

¹1917, Amer. Nat., pp. 316-317.

Table 1. Characters of the Lacrymal and Contiguous Elements in Temnospondyls, Branchiosaurs, and Microsaurs

	lacrymal present	la extending from orbit to nares	la-na contact	la-mx "	la-ju "	la-orbit "	la-pf "	la-po "	fr-mx "	na-mx "	na-ju "	pf-ju "	ju-seq "	jugal vestigial
Order Temnospondyli														
Loxommatidae														
<i>Loxomma allmani</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Trimerorhachidae														
<i>Trimerorhachis insignis</i>	+	+	+	+	+	+	+	+	○	○	○	○	+	○
Archegosauridae														
<i>Discosaurus permianus</i>	+	?	+	+	?	○	?	+	○	○	?	○	+	○
<i>Archegosaurus latirostris</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Archegosaurus decheni</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Actinodon frossardi</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Sclerocephalus labyrinthicus</i>	+	○	+	+	+	○	+	○	○	+	○	○	+	○
<i>Osteophorus raemeri</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Eryops megacephalus</i>	+	○	+	+	+	○	+	○	○	○	○	+	+	○
<i>Lydekkerina huxleyi</i>	+	○	+	+	+	○	+	○	○	○	○	+	+	○
<i>Nyrانيا trachystoma</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
Fam.?														
<i>Cochleosaurus bohemicus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
<i>Melosaurus uralensis</i>	?	○	?	+	?	○	?	+	○	○	+	+	+	○
<i>Chelydosaurus</i>	○?	○	○?	○?	?	○	?	○	○	+	+	+	+	○
<i>Dendrepelon deprivaturn</i>	+	○	+	+	?	○	+	○	○	?	○	+	+	○
Fam.?														
<i>Dasyceps bucklandi</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Fam.?														
<i>Acanthostoma vorax</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Brachyopidae														
<i>Bothriceps australis</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
Dissorophidae														
<i>Broiliellus</i>	+	+	+	+	○	+	+	○	○	○	○	○	+	○
Micropholidae														
<i>Micropholis stowi</i>	+	+	+	+	+	+	+	○	○	○	○	○	○	+
Mastodontosauridae														
<i>Mastodontosaurus</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Capitosaurus</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
<i>Cyclotosaurus</i>	+	○	+	+	+	?	○	+	○	○	○	+	+	○
<i>Trematosaurus</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
<i>Metopias</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
Order Uncertain														
Stegopidae	+	+	+	+	○	+	+	○	○	○	○	○	+	○

	lacrymal present	la extending from orbit to nares	la-na contact	la-mx "	la-ju "	la-orbit "	la-pf "	la-po "	fr-mx "	na-mx "	na-ju "	pf-ju "	ju-aq "	jugal vestigial
Order Phyllospondyli														
Apateonidæ														
<i>Melanerpeton pusillum</i>	○	○	○	○	○	○	○	○	○	+	+	+	+	○
<i>M. pulcherrimum</i>	○	○	○	○	○	○	○	○	○	+	+	+	+	○
<i>M. fallax</i>	?○	○	○	?+	?+	?+	?+	○	○	○	○	○	+	○
Branchiosauridæ														
<i>Protriton petrolei</i>	○	○	○	○	○	○	○	○	○	+	○	+	+	○
<i>Branchiosaurus</i>	○	○	○	○	○	○	○	○	○	+	○	+	+	○
<i>Dawsonia</i>	?	○	?	○	?	?	?	○	○	○	+	+	+	○
<i>Pelosaurus laticeps</i>	+	○	+	+	+	○	+	○	○	+	○	+	+	○
" "	+	{+}	+	+	+	{+}	+	○	○	+	○	{+}	+	○
" "	+	{+}	+	+	+	{+}	+	○	○	+	○	{+}	+	○
Hylonomidæ														
<i>Hyloplezion</i>	?○	○	○	○	○	○	?○	○	○	○	○	?+	?	○
Order Lepospondyli														
Urocordylidæ														
<i>Eoserpelon tenuicorne</i>	○	○	○	○	○	○	○	○	○	?○	○	+	+	○
<i>Scincosaurus (Keraterpeton) crassus</i>	?	○	○	?	?	?	?	○	○	○	○	○	+	○
<i>Diceratosaurus punctolineatus</i>	+	○	○	+	○	+	+	○	○	○	○	○	+	○
<i>Diceratosaurus laevis</i>	○	○	○	○	○	○	○	○	○	○	○	○	+	○
Diplocaulidæ														
<i>Diplocaulus</i>	+	○	○	+	○	○	+	○	○	○	○	+	+	○
Tutidanidæ														
<i>Erpetosaurus minutus</i>	○	○	○	○	○	○	○	○	○	○	○	○	+	○
" <i>tabulatus</i>	○	○	○	○	○	○	○	○	○	○	○	+	+	○
Amphibamidæ														
<i>Amphibamus</i>	+	○	+	+	○	○	+	○	○	○	○	+	+	○
Microbrachidæ														
<i>Microbrachis pelikani</i>	?	○	?	?	?	?	?	?+	○	+	?+	?+	?	?
Aistopoda														
<i>Dolichosoma longissimum</i>	?○	○	○	○	○	○	?○	○	○	○	○	+	+	○

Table 2.—Characters of the Lacrymal and Contiguous Elements in Palæozoic Reptiles

	lacrymal present	la extending from orbit to nares	la-na contact	la-mx "	la-ju "	la-orbit "	la-pf "	la-po "	fr-mx "	na-mx "	na-ju "	pf-ju "	ju-eq "	jugal vestigial
Cotylosauria														
Seymouriidae														
<i>Seymouria</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Diadectidae														
<i>Diadectes</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Pariasauridae														
<i>Pariasaurus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Limnoscelidae														
<i>Limnoscelis</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Captorhinidae														
<i>Labidosaurus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
<i>Captorhinus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Pantylidae														
<i>Pantylus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
Procolophonidae														
<i>Procolophon</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Pelycosauria (Theromorphs)														
Edaphosauridae														
<i>Naosaurus</i>	+	+	+	+	+	+	+	○	○	○	○	○	+	○
?Poliosauridae														
<i>Mycterosaurus</i>	+	○	?	+	+	+	+	○	○	+	○	○	+	○
Sphenacodontidae														
<i>Sphenacodon</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Therapsida														
<i>Scylacops</i>	+	○	○	+	+	+	+	○	○	+	○	○	+	○
Parapsida														
<i>Aræoscelis</i>	+	○	○	+	+	+	+	○	○	+	○	○	+	○

Table 3.—Characters of the Lacrymal and Contiguous Elements in Post-Palaeozoic Tetrapoda

	lacrymal present	la extending from orbit to nares	la-na contact	la-mx "	la-ju "	la-orbit "	la-pf "	la-po "	fr-mx "	na-mx "	na-ju "	pf-ju "	ju-eq "	jugal vestigial
Thecodontia														
<i>Euparkeria</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
<i>Mystriosuchus</i>	+	○	+	+	+	+	+	○	○	+	○	○	○	○
Crocodylia														
Crocodylidae														
<i>Alligator</i>	+	○	○	+	+	+	+	○	○	+	○	○	○	○
Rhynchocephalia														
<i>Sphenodon</i>	○	○	○	○	○	○	○	○	○	+	○	○	+	○
Squamata														
<i>Iguana</i>	+	○	○	+	+	+	+	○	○	+	○	○	+	○
<i>Boa</i>	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Aves	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Therapsida														
Cynodontia														
<i>Ictidopsis</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
<i>Cynognathus</i>	+	○	+	+	+	+	+	○	○	+	○	○	+	○
Mammalia														
Primitive Marsupialia	+	○	+	+	+	+	○	○	○	+	○	○	+	○
Primitive Placentalia	+	○	○	+	+	+	○	○	+	+	○	○	+	○

Cotylosauria

Dr. D. M. S. Watson, in his interesting paper (1917) on the classification of the pre-Jurassic Tetrapoda, says that he retains the superorder Cotylosauria "simply because of its use as a dumping-ground for those primitive reptiles which retain a roofed skull," and that even his orders (Seymouriamorpha, Diadectomorpha, Captorhinomorpha) are also "probably somewhat unnatural groups" and that "it would perhaps have been more satisfactory to raise the superfamilies to ordinal rank"—in other words, to expand the old order Cotylosauria into seven orders to include the forms clustering respectively around *Seymouria*, *Diadectes*, *Pariasaurus*, *Procolophon*, *Captorhinus*, *Limnoscelis*, and *Pantylus*. He also states that the real classification, i.e., that into families, is founded as far as possible on the characters of the brain-case. The writer, on the other hand, is impressed not only by the numerous resemblances between

the members of these seven groups, but also by the great changes in skull structure described by Dr. Watson, which take place independently in different families of the group. Some of these changes are the obliteration of the otic notch in the *Pariasauria* and in *Captorhinomorpha*, the turning down on to the nuchal surface of the dermosupraoccipitals and tabulars in *Pantylus* and in the captorhinomorphs, the development of a short, high, *Sphenodon*-like brain-case in *Procolophon*, the independent evolution of vertically placed quadrates in pariasaurs and captorhinomorphs, the depression of the inner ear in the captorhinomorphs, the upgrowth of the maxilla to gain contact with the nasals, and the concomitant retraction of the lacrymal in *Procolophon*. But the changes merely disguise, without obliterating, the bonds of affinity between these varied cotylosaurs, so that one may readily sense the relationship of *Limnoscelis* to the captorhinomorphs, of *Procolophon* to the diadectomorphs, and so forth. It seems quite possible that in this very primitive and plastic group of reptiles the level of the internal ear with respect to the floor of the brain-case might change as rapidly as the inclination of the quadrates to the midline of the skull, and that the secondary closing off of the inner ear from the brain-case is after all no great morphological accomplishment in comparison with many other transformations with which we are familiar.

In spite of such internal changes, the *Cotylosauria*, with the exception of *Procolophon*, are characterized by the constancy of the lacrymal region, in which the lacrymal always extends from the orbit to the nares and separates the prefrontal from the jugal and the nasal from the low ascending process of the maxilla. The arrangement of the lacrymal region, like the pattern of the skull as a whole, is closely allied to that of the rhachitomous stegocephs, in so far as the lacrymal is in contact with prefrontal, maxilla, and nasal; but it differs in the extension of the lacrymal from the orbit to the naris, a rare character among the Rhachitomi. The chief characters of the lacrymal region of the cotylosaurs are recorded in Table 2.

Chelonia

The loss, in this order, of several elements of the skull top, including the lacrymals, the usurpation of the place of the lacrymals by the prefrontal, and the upgrowth of the maxilla so as to gain contact with the prefrontals, are all signs of modernization, which have been paralleled in other groups (e. g., *Sphenodon* and *Ophidia*) and which mask, but do not obliterate, the evidence afforded by the remaining parts of the skull

and mandible of derivation from primitive reptiles, possibly allied to the *Pariasauria* (Jaekel). The reported occurrence in the Upper Triassic chelonian *Stegochelys* (*Triassochelys*) *dux* Jaekel (1916) of a separate lacrymal ("postnasal") extending from the anterior naris to the orbit will, if confirmed, afford further evidence in the same direction; meanwhile, a comparison of all views of the skull of this genus as figured by Jaekel with those of *Diadectes*, *Pantylus*, *Labidosaurus*, *Pariasaurus*, and *Procolophon* has revealed to the writer no decisive evidence in favor of the well-known view that the Chelonians are specially related to the diadectid cotylosaurs. Even less convincing is Boulenger's ingenious argument (1918) for regarding the Chelonians as relatives of *Sphenodon*. His hypothesis that the primitive Chelonians had fenestrated temporal regions and that the roofed-over condition of *Chelone* is entirely secondary must now reckon with the completely roofed condition in the Upper Triassic *Stegochelys* (*Triassochelys*), which, according to Jaekel's figures, is wholly unlike *Sphenodon* except in its primitive reptilian characters.

Pelycosauria (= Theromorphia)

The recent work of Broom, von Huene, Williston, and Watson, has developed the fact that in many characters the pelycosaurs are intermediate between the captorhinomorph cotylosaurs and the Therapsida. This conclusion is supported by the pattern of the lacrymal region. In *Naosaurus* and *Edaphosaurus* the lacrymal extends to the naris and all the relations of the lacrymal and contiguous elements, as recorded in Table 2, agree with the conditions in Cotylosauria. *Sphenacodon* and *Mycterosaurus*, on the other hand, exhibit successive stages in the retraction of the lacrymal and the upgrowth of the maxilla, which gains contact with the nasal as in the therapsid and other higher reptiles. Hence, the group as a whole is characterized by the transitional conditions of the lacrymal from the cotylosaurian to a higher reptilian stage.

Bolosaurus is referred by Broom and Watson to this group rather than to the Cotylosauria; its lacrymal region is of the captorhinid type; but so also is that of *Naosaurus*. The under side of the skull, as observed by Case and von Huene, strongly recalls the captorhinids, but here again *Naosaurus* and even *Dimetrodon* are not far off.

Casea, which was very doubtfully referred to this group by Williston and that only in a distinct suborder, resembles the *Dinocephalia* among the mammal-like series in many curious features of the skull and postcranial skeleton and, indeed, is referred by Watson to the "Anomodontia" or Therapsida. The sutures in the lacrymal region are not visible.

Therapsida

The labors of Owen, Seeley, Broom, Watson, Whaits, and Houghton on the South African mammal-like reptiles of the Permian and Triassic Karroo series, have revealed the wide adaptive radiation of this group.

The oldest known forms, the Dinocephalia, have already taken on some of the specializations of giantism, especially in their excessively short feet, huge thorax, massive skulls, and strong front teeth, fitted perhaps for tearing up tough vegetation. Notwithstanding these specializations, the Dinocephalia retain many ancient characters, such as the large pineal eye, the very primitive lower jaws, the position of the single temporal fenestra below the junction of the postorbital and squamosal, the presence of a small cleithrum and of two coracoid elements, the primitive atlas complex, the plate-like pubis and ischium, and the primitive relations of the tibia and fibula with the tarsus. In another series of characters they have advanced far beyond the crawling bent-kneed pelycosaur stage, and they are evidently heavy-bodied derivatives of a swift-moving type able to extend the knee and raise the body well off the ground. The lacrymal region is fairly primitive and, although the lacrymal is overgrown by the stout maxilla, it is in contact with the enlarged septomaxilla, this probably indicating that the lengthening of the face in this group is secondary.

The Dromasauria, of the Permian, are small lacertiform reptiles with a primitive skeleton, especially in the manus and pes. They have a primitive undifferentiated series of teeth all around the short mouth. The orbit is large and has apparently encroached upon the lacrymal, which is very short and in wide contact with the septomaxilla (Broom). The temporal region is primitive, allied to the dinocephalian type, and structurally ancestral to the specialized anomodont type. The latter is distinguished not only by the beaked jaws, but by the extreme shortening of the lacrymal region and backward prolongation of the zygomatic arch and fossa.

The Permian Gorgonopsia probably stand near the middle of the whole therapsid series. The typical genera retain the primitive position of the temporal fenestra below the postorbital-squamosal bar, and the palate and basis cranii are modified from the primitive pelycosaur type (Watson). The skull is of the predatory, compressed pelycosaur type, often with a festooned row of lanian teeth, but this may be largely a parallel development; that is, it is quite possible that the lengthening of the face is secondary. The lacrymal, as in the higher pelycosaurs, no longer extends to the nares and is overgrown by the enlarged maxilla.

The dentary exhibits a long coronoid process, or ascending ramus, a predatory adaptation, but fundamentally the jaw is allied to the primitive dinocephalian type. The limbs are often of the swift moving type, capable of extending the knees.

The Therocephalia closely resemble the Gorgonopsia in skull form, but the temporal fossa now extends up to the parietals, the postorbital-squamosal contact being lost; the palate develops vacuities near the ectopterygoids (Broom, Watson). The lacrymal region is similar to that of the Gorgonopsia. The Bauriamorpha are another predatory offshoot of the primitive Therapsida, comprising small animals which in some respects foreshadow the cynodonts. Some of them acquired oval-crowned grinding teeth.

The Triassic Cynodontia range in size from *Ictidopsis*, which was about as large as a common dasyure, to *Cynognathus crateronotus* with a skull about fifteen inches long. In *Cynosuchus* the general skull form is like that of the primitive Gorgonopsia, and the simple recurved teeth are arranged in a festoon. The lacrymal region, as described by Haughton, is essentially the same as it is in other members of this suborder. In *Ictidopsis* (Fig. 57) the molars are becoming triconodont. The lacrymal region is very marsupial-like, but the enlarged maxilla has not yet grown backward and upward above the lacrymal. In the higher cynodonts the molars vary from the shearing triconodont type of *Cynognathus* to the oval tuberculate crowns of *Diademodon* and its allies. The incisors and canines are of predatory submammalian type. The upper jaws widely overhang the lower. The mandible is submammalian in so far as the dentary is the predominant element with a wide ascending ramus, while the quadrate and articular are small and seemingly are about to be transformed into the incus and malleus. The palate is distinctly submammalian and the atrophy of the quadrate process of the pterygoid foreshadows the subsequent reduction of that element, which is so large in all other reptiles. The lacrymal region of *Cynognathus* and *Diademodon* is very mammal-like and is in harmony with the view that the cynodonts, as a group, are actually ancestral to the mammals. The expansion and overlap of the lumbar ribs is unique and suggests some radical changes in the musculature, possibly leading to the mammalian diaphragm and eventually to the loss of lumbar ribs and the substitution of apophyses from the centra. The shoulder girdle, humerus, and pelvis foreshadow the monotreme type and in the femur we have the beginnings of the mammalian trochanters.

In brief, the Therapsida range from relatively primitive Permian stages immediately above the pelycosaurs up to highly progressive Triassic types immediately below the mammals. It is customary to regard even the cynodonts as at most very remote relatives of the mammals, but it is now time to call for definite evidence in favor of this a priori assumption.

Parapsida

The most primitive well-known member of this series is perhaps *Palæohatteria*. Here the lacrymal is well developed, although not extending to the naris, and is barely excluded from the orbital border by a slight prefrontal-jugal contact, which recalls the conditions in many temnospondyls. In the relatively primitive Triassic ichthyosaurs and even in their descendants, the normal ichthyosaurs with enlarged orbits, the lacrymal still remains fairly primitive. The Squamata, on the other hand, are characterized by the early reduction of the lacrymal and the concomitant enlargement of the prefrontal—a line of specialization which culminates in the Ophidia in the complete loss of the lacrymal. In the Acrosauria (*Sauranodon*, *Pleurosauros*), also, the lacrymal is reduced and the prefrontal enlarged.

Rhynchocephalida

This series has generally been placed under the Diapsida, but it seems more likely that of its two supratemporal fenestræ the lower one was inherited from primitive pelycosaurs and the upper one was developed independently, just as it was in the true Archosauria, comprising the aëtosauers, phytosauers, crocodiles, dinosaurs, pterosaurs, and ancestral birds. The more primitive Rhynchocephalida (*Rhynchosaurus*, *Champsosaurus*) retain the lacrymal, with its normal reptilian contacts, but in *Stenomelodon* its place is partly usurped by the prefrontal, and in *Sphenodon* the lacrymal has been entirely lost.

Sphenodon presents a curious mixture of characters; the palate recalls both the captorhinid and the primitive lizard types; in the absence of the lacrymal and in the predominance of the prefrontal it parallels especially the Chelonia; while in the loss or fusion of the opisthotic it parallels all recent reptiles except the Chelonia; the skeleton as a whole is distinctly lacertiform, but in some points more primitive.

The derivation of the Rhynchocephalida from some primitive theromorph or pelycosaur is suggested by very many characters of the skull and skeleton in which the former are obviously more advanced than the latter.

Diapsida (Archosauria)

In all the primitive members of this relatively compact natural group (after the exclusion of the Rhynchocephalida, etc.), the skull is already compressed, with a high temporal region and a pointed face; the lacrymal is a large bone on the side of the face and is perforated by a large antorbital fenestra. This condition, with secondary modifications, persists in the earliest phytosaurs, dinosaurs, and pterosaurs, but has probably been lost in the Crocodilia. The birds probably sprang from some very early member of the diapsid series, but parallel the non-diapsid groups in the loss of the true lacrymal and the substitution of an enlarged prefrontal.

Prototheria, etc.

The grouping of the lower mammals into subclasses is in an unsatisfactory state owing to the poverty of the palæontological record and to the degraded and partly specialized conditions of the existing representatives of the Prototheria. The monotremes show strong evidence of remote affinity with the marsupials in the construction of the brain and of very many other parts of the anatomy. On the other hand, their skeleton is totally lacking in any clear marks of a former arboreal stage such as persists even in the most highly modified marsupials, so that it is unlikely that the monotremes ever passed through an arboreal stage. Their orbital region is peculiar not only in the total loss of the lacrymal but in the great expansion of the orbitosphenoid, extremely small frontals, loss or great reduction of the jugal, etc. These and other peculiar skull characters might perhaps have been derived from the conditions in the Multituberculata, as suggested by Broom (1914, p. 3), but, according to Matthew and Granger, the limb structure of *Ptilodus* is clearly against this view. Of the two existing monotremes, *Ornithorhynchus* is apparently the more primitive in many characters.

I have often considered the possibility that the monotremes might be derived directly from some such anomodont as *Lystrosaurus* through the expansion of the box-like cranium, the dwindling of the squamosal and posterior jaw elements, the degeneration of the beak into a leathery "duck-bill," etc. But the retention of marginal teeth in *Ornithorhynchus*, the lack of all positive evidence for direct derivation from either the anomodonts or the dinocephalians, and the evidence of the structural affinity of the monotremes with the marsupials and with the multituberculates are all against such an hypothesis.

Ptilodus, as Mr. Gidley has shown, has numerous skull characters in common with marsupials and, even if Broom's view that the multituberculates are related to the monotremes should be confirmed, it would perhaps only indicate that the monotremes, as well as other multituberculates, have been derived from primitive Metatheria.

The affinities of *Tritylodon* are very puzzling. Its "multituberculate" dentition is very unlike that of *Plagiaulax* and *Ptilodus*, and its resemblances to the typical multituberculates are remote. According to Broom, the lacrymal region is mammalian in type, as it has lost the prefrontal.

In order to discuss effectively the interrelations of the Tertiary groups of mammals in which the lacrymal region is known, it will be necessary to consider briefly the interrelations of the Mesozoic mammals, in which unfortunately the whole skull is unknown, only jaws and teeth being preserved. Among these, the triconodonts are of interest in the present connection only in the fact that they may possibly be allied, on the one hand, to the Protodonta and thus eventually to the cynodonts and, on the other, to the multituberculates and primitive Metatheria. The remarkable diversity in the dentition of the Purbeck (Upper Jurassic) triconodonts and trituberculates, and the sharp differentiation of these two groups even in the Stonesfield Slate (Lower Jurassic) shows that the common ancestral source must be at least of Upper Triassic age, where they were perhaps represented by the Protodonta. The affinities of the Trituberculata are discussed below.

Metatheria

The known Marsupialia, in spite of their wide adaptive radiation, are a rather compact natural group, the more primitive members of the polyprotodont and diprotodont suborders retaining a long series of characters indicating a common origin, possibly in the early Tertiary but not far back in the Mesozoic. The construction of the lacrymal region, while subject to minor variations, reveals several details which are characteristic of the group, especially the tendency for the lacrymal to develop a prominent antorbital rim which is produced dorsoposteriorly. The lacrymal-nasal contact which sometimes occurs may well be a primitive marsupial character. In the more primitive marsupials the lacrymal foramen is behind the antorbital rim, but with advancing specialization it first notches the rim and may even move forward a little in front of it.

The evidence of the lacrymal region is in harmony with the view that the cænolestoids are allied with the Peramelidæ among the Polyprotodontia.

Myrmecobius, in its lacrymal region as well as in the dentition, is merely a specialized dasyurid.

Wynyardia is extremely primitive in the lacrymal region and is probably a primitive diprotodont.

Placentalia

With regard to the Mesozoic Trituberculata, the jaw and dentition indicate that the Lower Jurassic *Amphitherium* was ancestral to *Amblotherium* and other minute insectivorous genera of the Purbeck beds, which are of Wealden age. Owen regarded them all as marsupials but, on account of the form of the angle of the jaw, they may be very primitive placentals. Probably their *Notoryctes*- and *Chrysochloris*-like molars do not indicate any close affinity either with the marsupials or with the zalambdodont placentals. On the other hand, *Amphitherium* itself may stand near the common source of both the Marsupialia and the Placentalia, as suggested by the extremely primitive dentition.

The lacrymal problem in its phyletic and taxonomic bearings is closely connected with the problem of the origin of the placental mammals. Was there ever a single relatively compact natural group of primitive placentals, the source of all the now extremely diversified placental orders? Or have these been derived independently from widely different metatherian groups? If the former is true many at least of the "primitive placental characters" have been derived by inheritance from the ancestral group; if the latter, then these supposedly primitive characters are of convergent derivation.

In the case of the marsupials it is practically certain that we have to do with a natural group for, although extremely diverse in habitus, they are tied together by such a long series of peculiar characters of the dentition, skull, limbs, brain, reproductive organs, etc., that a common origin is practically demonstrated.

The placental radiation, however, is so much older, or at least has progressed so much farther, that among its modern representatives the greater part of the ancestral heritage has been concealed or destroyed by cœnotelic modifications, and we find accordingly that, apart from the presence of a corpus callosum and of an allantoic placenta, there are not many typical characters which hold good of the entire series.

As far back as the Lower Eocene the adaptive radiation of the placentals had gone so far that nearly all the modern orders were well differentiated from each other, and even in the Paleocene there were such highly specialized mammals as bats and stylinodonts. The great

collections of Paleocene and Eocene mammals made by this Museum are constantly increasing the number of Eocene mammals of isolated position and of relatively high specialization, so that the placental radiation must have commenced far back in the Mesozoic.

On the other hand, these collections, which are now being described by Matthew and Granger, are also increasing the number of known forms which unite in themselves characters that were later distributed among different orders, and which multiply the number of apparent connections between diverse placental groups. Here belong many of the genera which Matthew has provisionally referred to the *Insectivora*, pending the determination of their true positions.

Cope's view of the ultimate unity of origin of the placentals was based partly on his observation that in the Paleocene and Lower Eocene most placental families preserved clear evidence of derivation from primitive stocks with tritubercular upper and tuberculosectorial molars, a conclusion which has been greatly strengthened by subsequent research, especially by Osborn and Matthew. Cope was also impressed by the prevalence in the Paleocene and Lower Eocene of placental mammals with very primitive five-toed hands and feet. It was largely the detailed characters of the limbs and feet which led Matthew (1904) to the generalization that the placentals, as well as the marsupials, had been derived from primitive arboreal ancestors with a "more or less opposable" first digit on both the manus and the pes.¹

The humeri of Paleocene and Eocene mammals seem to give testimony in the same general direction, and after a somewhat extended comparative study (1920, pp. 64-78) I reached the conclusion that in the primitive placentals of the Mesozoic the well-developed forearms were probably capable of a variety of movements as in climbing. It is also highly probable that these primitive unguiculate placentals were quite small, small enough to crawl easily through the underbrush and not so heavy as to make extreme specializations for climbing necessary. Their small size seems a safe inference from the facts that in every case in which the history of the group is well known the phyla run back into small forms with a more or less primitive dentition and skull, and that the varied trituberculate mammals of the Mesozoic were really minute in size.

¹This conclusion is contested by Mr. J. W. Gidley in a brief paper (1919) which was received after the present manuscript was fully written. A criticism of this paper lies beyond the scope of the present work.

Other characters which may provisionally be assigned to these primitive placentals are as follows: manus and pes relatively short, with gently spreading digits and partly divergent pollex and hallux; skull macrosmatic, with brain-case very small, sagittal crest and jaw stout; orbits small, postorbital processes incipient; lacrymal forming part of the prominent antorbital rim, behind which was the lacrymal foramen; lacrymal in contact with jugal, a well-defined fronto-maxillary contact above lacrymal; dental formula of adult— $I \frac{3}{1}$, $C \frac{1}{1}$, $P \frac{4}{1}$, $M \frac{3}{1}$; of young— $DI \frac{3}{1}$, $DC \frac{1}{1}$, $DP \frac{4}{1}$; incisors small, not specially modified, canines of moderate size, subcaniniform, not premolariform; premolars simple, except p^4 , upper molars tritubercular; lower molars tuberculosectorial; diet various, including insects, the nestlings of birds, eggs, fruits, etc.

CARNIVORA.—The classification of the major groups of Carnivora by Matthew (1901, 1909, 1915) is also an expression of the adaptive radiation and phylogeny of the Creodonta and Fissipedia.

At the base of the series are the Oxyclænidae, which are among the most primitive of all known placental mammals, not only in the dentition but also in the skull, including the lacrymal region (cf. page 146). The skeleton as a whole will shortly be described by Matthew. Meanwhile, it may be noted that the manus of the Lower Eocene *Chriacus gallinæ* (Matthew, 1915, p. 6) is of a very primitive placental type, with short spreading metacarpals, partly divergent pollex and strong claws, the whole being not unlike the climbing manus of the modern *Cercoleptes*. It seems highly probable that this general type of manus, adapted both for climbing and walking, is nearer to the primitive arboreal placental stage than is the compressed and more or less elongate manus of cursorial carnivores.

Closely related to the Oxyclænidae are the Arctocyonidae. In these the dentition is less primitive but the manus and pes of *Clænodon*, as described by Matthew (1901), are even better adapted for grasping and climbing. The Oxyclænidae and the Arctocyonidae are grouped by Matthew as Procreodi because their p_4 and m_1 are not specialized as carnassial teeth. The dental and other characters of *Thryptacodon* (Matthew, 1915, p. 9) of the Oxyclænidae suggest that there is "probably a near affinity between the less specialized Arctocyonidae, and the Cercoleptoid Miacidæ and the Oxyclænidae, although part of the resemblance is due to parallelism" (Matthew, *op. cit.*, p. 9).

The Miacidæ constitute the division Eucreodi of Matthew, so named because their p_4 and m_1 are specialized as carnassial teeth as in modern

Fissipedia, to which this group is also closely allied in all parts of the skeleton. The pes of *Didymictis* (Matthew, 1915, p. 26) is of semiplanti-grade type, but becoming better adapted for running. The feet of *Vulpavus*, *Miacis*, and *Vassacyon*, according to Matthew, are more "arboreal" in type. The lacrymal region of this family (p. 148) foreshadows the conditions in the modern Carnivora but is more primitive.

The Pseudocreodi of Matthew include the typical and best known creodonts, such as *Hyænodon* and *Patriofelis*, in which the carnassial teeth are behind p_4 and m_1 . In these animals the skeleton is, on the whole, less primitive than that of the Oxyclænidae, being often adapted for running. The muzzle is elongate and with it the pars facialis of the lacrymal. The late members of this group are large and specialized, but the earlier stages are smaller, and the trend is toward the Oxyclænidae as a central type.

The Acreodi of Matthew, including the Triisodontidae, are distinguished by the lack of normal carnassial teeth. The more primitive members (Triisodontidae) have tritubercular molars, which approach the primitive oxyclænid type. The more specialized Acreodi finally attain gigantic size and have various aberrant types of molars. The muzzle becomes long and with it the pars facialis of the lacrymal. The limbs of the late Mesonychidae are of subcursorial type.

The Fissipedia include two rather widely separated groups, the *Æluroides* and the *Arctoidea*, which were possibly derived independently from the Eucreeodi. Their lacrymal is often reduced and sometimes vestigial. The skeletons show a wide adaptive radiation for climbing, swimming, running, etc.

The Pinnipedia seem to be a very early offshoot of the primitive *Arctoidea*, which they resemble in the enlargement of the maxilloturbinals and in the auditory and lacrymal regions. That they are not modified Pseudocreodi is indicated by the reduction in number of the true molars, by the consolidation of the scaphoid, lunar, and centrale, and by the detailed characters of the lacrymal region.

INSECTIVORA (Lipotyphla).—The existing lipotyphlous Insectivora are all more or less highly specialized and degraded remnants of primitive Mesozoic placentals, which would perhaps be well represented by *Amphitherium*. Not much is left of the conception of the Insectivora as a primitive order, because most of their purely insectivorous adaptations are rather high specializations which outnumber such primitive placental characters as they still preserve. It is rather from the primitive Paleocene and Eocene representatives of the Creodonta, *Tænio-*

donta, Taligrada, Condylarthra, etc., that a more accurate concept of the stem placentals is now being derived.

The least specialized insectivores that are known from well-preserved skulls are the early Tertiary Leptictidæ which in the Eocene gave rise to the Erinaceidæ. Their lacrymal region is comparatively primitive, especially in *Ictops dakotensis* (Fig. 104). In the Erinaceidæ the pars facialis becomes further reduced, the foramen becomes marginal and the pars orbitalis expands. Quite characteristic is the peculiar mode of the reduction of the jugal, which finally becomes a vestige embedded in the middle of the zygomatic arch.

The Zalambdodonta are a very ancient stock, only remotely related to the Erinaceoidei. Matthew (1913) has shown that in the Paleocene zalambdodont *Palæoryctes* the molar pattern distantly approached a more normal tritubercular type, while in most of the later zalambdodonts the peculiar V-shaped form is secondary, not primitive. The recently described *Nesophontes* of Anthony, a subfossil insectivore from Porto Rico and Cuba, tends strongly to connect the soricoidei as a branch of the primitive zalambdodont stock. The lacrymal region in the zalambdodonts, while more or less degenerate, is quite characteristic in appearance (see page 165).

EDENTATA.—The Edentata have often been regarded as an excessively ancient branch of the mammals, almost deserving of subclass rank, but recent studies of Matthew (1918) give evidence that this order has undergone a very wide adaptive radiation during the second half of the Tertiary, during which the tree sloths were derived from ground sloths allied to *Hapalops*, the ant-eaters from others allied to *Scelidotherium*. This conclusion is supported by the patterns of the lacrymal region as described on pages 167 and 168 below. The affinity of *Hapalops* to the tree sloths in the lacrymal region is very clear, while *Scelidotherium* is plainly more primitive than the Myrmecophagidæ. Dr. Matthew shows also that the armadillos and glyptodonts, on the other hand, are the remnants of an older, early Tertiary stock, probably allied to the palæanodonts of Matthew. The lacrymal region of armadillos (pp. 168, 169) is quite distinct from the primitive ground-sloth type.

PHOLIDOTA.—The Pholidota also appear to be derived from this primitive edentate source (Matthew). Their lacrymal is highly degraded and specialized.

TUBULIDENTATA.—The Tubulidentata, on the other hand, have no relations with the edentates and are more probably highly specialized offshoots of the primitive Taligrada or Condylarthra. The great in-

crease in the pars facialis of the lacrymal is associated, as in many other instances, with the elongation of the snout and with the expansion of the olfactory chamber and adjacent sinuses.

TÆNIODONTA.—The more primitive Tæniodonta, such as *Onychodectes*, are now regarded by Matthew as allied to the palæanodonts and primitive edentates. The lacrymal region and, indeed, the whole skull and dentition of the Paleocene *Onychodectes* are very primitive and tend to connect this group with other primitive placentals, especially the Insectivora (Matthew).

LAGOMORPHA.—Mr. Gidley (1912) has emphasized the fact that even the Oligocene Lagomorpha are very highly specialized and widely different in the dentition and limbs from the other rodents. He, therefore, has raised the Lagomorpha to ordinal rank. While accepting this arrangement provisionally, I conclude from a comparison of the auditory, lacrymal, and basicranial regions, dentition, etc., of lagomorphs with those of the Eocene Ischyromyidæ that, on the whole, the latter represent a structural stage through which the lagomorphs must have passed if they were derived from any primitive placentals, as their brain, reproductive organs, etc., clearly indicate. The queer characters of the dentition cited by Mr. Gidley and the cursorial or saltatorial adaptations of the limbs are specializations beyond the more primitive conditions preserved in the Ischyromyidæ, although I do not suggest that they were actually derived from that family.

RODENTIA.—Even Messrs. Miller and Gidley (1918) are at present willing to admit that after the exclusion of the Lagomorpha the remaining rodents form a natural group, and by extending the work of Brandt and of Tullberg they have recently given a remarkably detailed picture of the multitudinous branches and subbranches of the adaptive radiation of this order. They will not admit that the Eocene Ischyromyidæ are ancestral to any of the later superfamilies and families, as held by Matthew (1910), and apparently believe that, since several of the existing families are well established in the Oligocene, the origin of the order must be sought far back in the Mesozoic.

As the evolution and consequent taxonomic characters of the lacrymal of rodents have been conditioned in part by the evolution of the gnawing apparatus, we must consider both together. The least specialized condition is preserved in the Ischyromyidæ, in which the greatly enlarged premaxilla had already extended dorsoposteriorly above the maxilla, gaining a wide contact with the frontal and restricting the maxilla. The lacrymal is consequently reduced to a small element on

the anterior rim of the orbit. The enlarged jugal retains its primitive contact with the lacrymal. The lateral sheet of the masseter probably ended anteriorly in a tubercle borne on the zygomatic branch of the maxilla, beneath the orbit.

In the modern *Arctomys*, representing the Sciuromorpha, the lacrymal is further restricted, but otherwise the lacrymal region is essentially unchanged. A branch of the masseter lateralis now extends in front of the masseteric tubercle, on to the maxilla, in front of the orbit, and this is the sole important difference in this region between *Arctomys* and the Eocene *Paramys*. Now as this preorbital extension of a branch of the masseter is obviously a new adaptation which was not yet developed in the Ischyromyidæ, I can see no good reason for using the primitive condition of that family as evidence for excluding *Paramys* from the ancestry of the Sciuromorpha, especially as the dentition of *Paramys* plainly relates it to that series.

In *Castor* the lacrymal is further restricted and the very powerful preorbital external branch of the masseter has conditioned the great strengthening of the jugal and the deep incision of a groove on the side of the maxilla. Somewhat similar conditions are found in the geomyid series, which, like the castorids, are specialized derivatives of the primitive sciuromorph stock.

In the myomorphs a further reduction of the lacrymal occurs, along with an opening up of the upper part of the infraorbital canal due to the invasion of a medial slip of the masseter.

In the dipodomorph series this medial slip becomes of enormous size, excavating a huge fenestra in the maxilla in place of the infraorbital canal and crowding the masseter lateralis away from the rostrum. The lacrymal in this series forms part of the dorsal brace for the zygomatic arch.

Finally, in the hystricomorphs, the jugal withdraws entirely from this brace, which is formed either chiefly by the maxilla or by the maxilla plus the enlarged lacrymal (Caviidæ); the deep fossa for the masseter medialis now extends far forward on to the premaxilla. In view of the extreme specialization of the molar teeth and of the lower jaw in the hystricomorphs, the conditions above described appear to be equally specialized. Finally, as all this is in complete harmony with the evidence afforded by successive stages of evolution of the jaws and dentition, I believe that the foregoing is a true account, not only of the evolution of the lacrymal and zygomatic region, but of the general evolutionary stages of the groups represented, and therefore accept fully the conclu-

sions of Dr. Matthew that, at least with regard to structural characters, the Ischyromyidæ are ancestral to all the remaining rodents.

TILLODONTIA.—In the Tillodontia the skull pattern, including the lacrymal region, is derived from the primitive placental type and is related to the primitive creodont type.

CETACEA.—The Cetacea are true placental mammals, and I believe that their origin is less excessively remote than the high specialization of existing forms would suggest. As remarked above (p. 158), the various Tertiary cetaceans tend to bridge the gaps between the Odontoceti and Mystacoceti on the one hand and the Archæoceti on the other. The characters of the lacrymal region further strengthen the evidence of relationship. The derivation of the whole order, through *Protocetus*, from the Hyænodontidæ, as suggested by Fraas, has been favorably viewed by Andrews, Abel, and others, but is doubted by Matthew. A review of the dental and cranial characters of *Protocetus* leads to the tentative conclusion that if the archæocetes are related to the hyænodonts it is probably by descent from primitive Pseudocreodi (Matthew). Other possibilities, such as relationship with the achænodont Artiodactyla, have been considered but do not seem probable.

ARTIODACTYLA.—The Artiodactyla are a group of ancient origin and uncertain affinities. They are, at least, far removed from the Perissodactyla with which they were formerly bracketed under the term *Diplarthra* of Cope. Even in their Lower Eocene representatives the typical artiodactyl foot structure was already established and, while the dentition runs back to primitive quadri- and tritubercular stages, it shows no special approach to that of any other group. The large size of the lacrymal, especially of the pars facialis, is very characteristic, except in a few cases. The order may possibly be related to the stem of the creodonts, but even the most primitive Eocene Dichobunidæ are already typical artiodactyls. The recently described Eocene genus *Creotarsus* may, when better known, throw some light on the origin of the order (Matthew).

AMBLYPODA.—The Amblypoda, as defined by Osborn, include a wide range of forms from the smaller Paleocene Periptychidæ to the gigantic, excessively short-footed Dinocerata of the Middle Eocene. The smaller, more primitive families, forming the order or suborder Taligrada, are very primitive placental mammals with tritubercular dentition and primitive limbs. Some of them may be allied to the Mioclænidæ among the Condylarthra (Matthew). In *Periptychus* and *Pantolambda* the limbs are very stout, with short hands and feet not far

from the primitive climbing placental type. The lacrymal, known in *Ectoconus* and *Pantolambda*, is very primitive; in the Dinocerata it is spread out on the inner wall of the orbit. This order and other short-footed ungulates, such as the Embrithopoda and Proboscidea, all appear to me to be derived from primitive short-footed procondylarths.

EMBRITHOPODA.—The Embrithopoda differ widely from the Dinocerata, as noted by their describer, Dr. Andrews, who has suggested remote relationship with the Hyracoidea. Their lacrymal region is comparatively primitive, but does not afford much evidence on this point. *Arsinoitherium* may prove to be a graviportal derivative of some condylarth stock, paralleling the rhinoceroses and astrapotheres in molar pattern.

PYROTHERIA AND BARYTHERIA.—The genetic relations of the Pyrotheria and Barytheria with the Proboscidean-Sirenian stem will shortly be discussed by Professor Loomis.

PROBOSCIDEA AND HYRACOIDEA.—The Proboscidea and Hyracoidea were often supposed to be related groups, but they were already very different even in very early Tertiary times and they may rather be quite independent offshoots perhaps from the Condylarthra. Even the oldest known proboscidean, *Mæriotherium*, is far more specialized in skull and dentition than any condylarth. While the structural gap between the two groups is too great to permit positive statements, it seems probable that every one of the specialized characters of the dentition of *Mæriotherium* has been derived from the far more primitive conditions in some such primitive procondylarth as *Hyopsodus walcottianus* Matthew (1915, p. 322), which has primitive, gently procumbent incisors, small canines, and the right kind of premolars and molars. This conclusion is a natural inference from what is known of the course of evolution of the dentition in parallel cases. The specialized incisors and small canines of *Mæriotherium* are surely derived from the far more primitive placental conditions represented in *Hyopsodus walcottianus*; its molars, while still quadritubercular, show the beginnings of the lophodont modification which has masked their primitive placental characters; its upper premolars, however, are relatively primitive derivatives of an *Hyopsodus*-like type; and the same is true of the lower premolars and molars.

Similarly, with regard to foot structure, both the manus and the pes of *Elephas* are simply gigantic and brachypodal modifications of a primitive condylarth type. This conclusion will probably be rejected as too speculative by most palæontologists, and is here recorded rather as a prophecy than as a thesis capable of satisfactory demonstration, but I

suspect that the primitive hyopsodont Condylarthra are a much better starting point than the Taligrada for the line that culminated in the Proboscidea. As to the relations of the Mæritheriidae, while it is quite possible that *Mæritherium* is related to the Sirenia (Osborn, 1909) the numerous detailed and peculiar resemblances to *Palæomastodon* in dentition and skull structure fully support Dr. Andrews in regarding it as the most primitive known member of the Proboscidea.

The lacrymal region of Proboscidea (p. 180) is specialized through the forward shifting of the orbits and thus affords no definite evidence of relationship with more primitive groups. The lacrymal region of *Mæritherium* is far more primitive than that of *Palæomastodon* and, in connection with other evidence, it supports the view that *Palæomastodon* was derived from a *Mæritherium*-like stage.

SIRENIA.—The Sirenia, although very highly specialized for aquatic life, show special resemblances with *Mæritherium* in the skull (including the orbital region) and dentition, and are generally regarded as a derivative of the proboscidean stem.

CONDYLARTHRA.—The Condylarthra, as recently revised by Matthew and Granger (1915, Parts 2 and 3), include, in addition to the Phenacodontidae (Paleocene and Lower Eocene), the families Miocænidae (Paleocene), Hyopsodontidae (Lower to Upper Eocene), Meniscotheriidae (Lower Eocene), and possibly also the Pleuraspidotheriidae (Paleocene, Europe). The Lower Eocene *Phenacodus* was regarded by Cope as the five-toed atavus of the hoofed mammals and in popular writings has often been referred to as the oldest known stage in the evolution of the Equidae. But Matthew (1897) showed that its "serial" foot structure is not primitive but derived from the more primitive conditions in the Paleocene *Euprotogonia* (*Tetrachodon*), its direct ancestor, and Osborn (in the forthcoming monograph on the Titanotheres) regards it as having no relationship with the contemporary perissodactyla. *Ectocion*, however, of the same family, is regarded by Granger (1915) as "presenting the type of upper molar from which the perissodactyl molars might have been derived" and the same may be said of the lower molars and of the upper and lower premolars. The lacrymal region (p. 176) in this family is known only in *Phenacodus*, where it is fairly primitive but not specially akin to the perissodactyl type. While *Phenacodus* itself is not an ancestor of the Perissodactyla, it retains many characters in the skull and skeleton which tend to support the view that the remote ancestors of the hippoid and other Perissodactyla once passed through a condylarth stage resembling *Ectocion* (Gregory, 1910, pp. 387-397, 450-451).

The fact that *Phenacodus* has a ball and socket lower ankle joint while the known perissodactyls have a hinge joint is not, I think, a valid objection to the foregoing conclusion, since the hinge joint is a progressive character of the perissodactyls, while the ball and socket ankle joint is a primitive placental character. The serial manus of *Phenacodus*, as above noted, is probably a specialized generic character.

The Meniscotheriidae (Granger, 1915) are widely different from the *Phenacodontidae* in dentition and skull as well as in the proportions of the limbs. They have short, spreading hands and feet of primitive placental type, in contrast with the narrower, more tridactyl feet of Phenacodonts. Their lacrymal region is also primitive (p. 175).

Their bunolo-phoselenodont upper molars present a complex crown-pattern which differs from those of the Eocene titanotheres and chalicotheres chiefly in the stronger development of the proto- and metaconules. The lower molars and both the lower and upper premolars also have many points of resemblance with the corresponding parts in chalicotheres and titanotheres. Many other resemblances to these groups, mixed with much more primitive placental characters, are revealed by a study of the skull, vertebræ, humerus, femur, radius and ulna, tibia and fibula, astragalus, manus and pes of *Meniscotherium chamense terrærubræ*. Obviously, however, this Lower Eocene meniscothere is not ancestral to the titanotheres, and probably not to the chalicotheres.

The Phenacodontidae, Hyopsodontidae, and the Mioclænidae run back into very small and extremely primitive species in the Paleocene, which have bunodont tritubercular molars and are not far from the primitive arboreal placental stock. They are, in fact, so primitive that it is only recently that Matthew and Granger have been able to show that they are Condylarthra. Thus, the order Condylarthra is of great phylogenetic interest. Unfortunately, its best and most widely known member, *Phenacodus primævus*, of the Lower Eocene, represents the most specialized stage of its own phylum and never deserved the high place once assigned to it as the "atavus of the hoofed mammals." Nevertheless, the order is probably related, through some of the smallest and oldest members, on the one hand with the primitive arboreal placentals and on the other hand with the Peripitychidae, the Perissodactyla, the Proboscidea, the Hyracoidea, and all the orders of extinct South American ungulates.

The Mioclænidae, which are referred to this order, are perhaps even more primitive than any known creodont, and some of the smallest mioclænids may stand near the source of the Primates.

HYRACOIDEA.—The Hyracoidea of the Lower Oligocene of Egypt are already specialized, both in skull structure and in dentition, and afford but little clue as to the origin of the group. The bunoselenodont upper molars and relatively advanced premolars might have been derived, partially by the reduction of the “conules,” from those of a *Meniscotherium*-like condylarth. The Hyracoidea resemble certain Perissodactyla in a number of characters, and may well be a partly parallel offshoot from the pro-Condylarthra. The lacrymal region of the older forms is allied to the primitive condylarth type, but more specialized.

NOTOUNGULATA, ETC.—The extinct South American ungulates, excepting the pyrotheres, exhibit a great adaptive radiation, of which the several branches parallel the Perissodactyla, the Hyracoidea, and in some cases the Rodentia, in body form, dentition, and foot structure. The rodent-resemblances of the typotheres are pure analogies, but the perissodactyl and hyracoid characters are probably due to the independent derivation of all these groups from primitive Condylarthra. Thanks to the labors of Burmeister, Ameghino, Lydekker, Roth, Scott, and others, it is established that the South American ungulates include three very distinct orders, the Litopterna, the Notoungulata, and the Pyrotheria. The Litopterna run back into small forms with relatively primitive dentition, which in some cases suggest condylarth types. The Notoungulata have rhinocerotoid molars, but often with an “accessory pillar” in the lower molars and extra folds in the upper.

The lacrymal region of the Litopterna and Notoungulata, so far as known, is readily derivable from the condylarth type.

PYROTHERIA.—The Pyrotheria, according to Professor Loomis, may be related to the Proboscidea and Sirenia.

PERISSODACTYLA.—The very numerous and diversified perissodactyls of the Eocene have been studied and described by many writers, including Cope, Kowalevsky, Osborn, Schlosser, Depéret, Stehlin, Matthew, Granger, and others, who have worked out the systematic relations and evolution of the different families. Professor Osborn (1898) has divided the order into five superfamilies, Hippoidea, Tapiroidea, Rhinoceroidea, Chalicotheroidea, and Titanotheroidea. These superfamilies may be considered under two series, the first, or plagiolophodont series including the horses, palæotheres, tapirs, lophiodonts, rhinoceroses and their allies, and the second, or bunolambdodont series, the chalicotheres, lambdotheres, and titanotheres. The plagiolophodont series tend to have bunolophodont to buno-lophoselenodont molars,

with prominent oblique proto- and metalophs; their premolars are often precociously molarized; the manus and pes are, usually, progressively mesaxonic. Starting with small subcursorial forms like *Eohippus* and *Systemodon*, they give rise to a great adaptive radiation of graviportal and cursorial phyla, with the well-known specialized dentitions of the horses, tapirs, rhinoceroses, and allied families. The related bunolambdodont group, on the other hand, shows a strong tendency to develop bunolambdodont molars with more or less reduced proto- and metalophs, which become vestigial in many titanotheres; the premolars are imperfectly and slowly molarized; and the fore feet pass from the mesaxonic either to the paraxonic or to an asymmetrical arrangement.

In both series the nasals are large and are originally in contact with the lacrymals. All the superfamilies run back to the stem of the Perisodactyla.

MENOTYPHILA.—The Menotyphla are widely removed from the typical Insectivora or Lipotyphla and are probably related to the stem of the Primates, with which they agree in many important characters. But the separation of the two orders probably took place as far back as the Paleocene, since the Paleocene and Lower Eocene Plesiadapidae, which appear to be Menotyphla, were already distinct from, although related to, the Primates.

The lacrymal region of the modern Menotyphla is specialized by the inflation of the sinus in its interior, paralleling that of *Lemur* in the great extension of the pars facialis.

DERMOPTERA.—The Dermoptera are at the present time an isolated group apparently related remotely to the Menotyphla and to the Chiroptera. As noted by Matthew (1918), the group was possibly represented in the Lower Eocene by the genus *Plagiomene*.

CHIROPTERA.—The Chiroptera date back at least to the Paleocene (Matthew, 1917) and are perhaps remotely related to the Menotyphla-Primate stock. They apparently tend to confirm the theory of the arboreal origin of the placentals and their source must be sought among the primitive bunodont, insectivorous-frugivorous mammals.

PRIMATES.—The premolars and molars of the most ancient and primitive Primates resemble in many characters those of the smallest mioelænid Condylarthra, and it is possible that Cope may eventually be justified in his opinion that the Condylarthra were ancestral to the Primates as well as to many other orders. From the first the dentition is of the bunodont frugivorous-insectivorous type and the primates avoid both the shearing and the advanced lophodont modifications of other orders.

The foot structure of the Eocene primates (*Adapidæ*, *Tarsiidæ*) is already completely arboreal in type, with elongate phalanges, more or less flattened ungues and sharply divergent hallux. Such hands and feet can never have been derived from specialized terrestrial types and their characters seem to lend support to Dr. Matthew's conclusion (1904) that the stem placentals were more or less arboreal in habit. The pes is literally condylarthrous, as the ankle-joint is of the ball and socket type.

The lacrymal region even of the Eocene primates was already specialized in the reduction of the pars facialis, but is otherwise of primitive placental type, which affords no very definite evidence of the origin of the group.

REFERENCES TO LITERATURE

- ABEL, O. 1902. Les Dauphins Longirostres du Boldérien (Miocène Supérieur) des Environs d'Anvers. Mem. Mus. Roy. d'Hist. Nat. Belgique, II, pp. 105-188, Pls. XI-XVIII. [Lacrymal region of *Eurhinodelphis* and others.]
1912. Cetaceenstudien, III Mittheil.: Rekonstruktion des Schädels von *Prosqualodon australe* Lyd. aus dem Miozän Patagoniens. Sitzungsber. k. Akad. der Wissen., Mat.-Naturw. Klasse, CXXI, B, parts 1-3, Abteil. I, s. pp. 57-75, Pls. I-III.
1914. Die vorzeitlichen Säugetiere. Jena. [Skulls of Miocene Cetacea: *Agorophius*, *Patriocetus*, etc.]
1919. Die Stämme der Wirbeltiere. 8vo. Berlin and Leipsic.
- ADAMS, L. A. 1919. A Memoir on the Phylogeny of the Jaw Muscles in Recent and Fossil Vertebrates. Ann. N. Y. Acad. Sci., XXVIII, pp. 51-166, Pls. I-XIII.
- ALLIS, E. P. 1897. The Cranial Muscles and Cranial and First Spinal Nerves in *Amia calva*. Journ. Morph., XII, No. 3, pp. 489-770, Pls. XX-XXXVIII. [Excellent figures of the skull.]
- ANDREWS, C. W. 1906. A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt. London. [References to lacrymal region of *Arsinoitherium*, *Mærittherium*, *Palæomastodon*, *Prozeuglodon*.]
- ANTHONY, H. E. 1918. The Indigenous Land Mammals of Porto Rico, Living and Extinct. Mem. Amer. Mus. Nat. Hist., N. S., II, part 2, pp. 334-345, Pls. LV-LXXIV. [Skulls of *Nesophontes* and other mammals.]
- ATTHEY, T. 1876. On *Anthracosaurus russelli*. Ann. Mag. Nat. Hist., (4) XVIII, pp. 146-167, Pls. VIII-IX. [Lacrymal region, Pl. VIII.]
- BARDELEBEN, K. v. 1896. Ueber das Präfrontale und Postfrontale des Menschen. Verhandl. d. Anat. Ges. a.d. 10. Versamml. in Berlin, 1896, pp. 153-154. [Suggests that frontal process of human maxilla = prefrontal bone of lower vertebrates.]
- BAUR, G. 1896. The Stegocephali, a Phylogenetic Study. Anat. Anz., XI, pp. 657-673. [Stegocephali derived from Devonian Crossopterygii.]
- BEMMELEN, F. F. van. 1901. Der Schädelbau der Monotremen. Jen. Denkschriften, VI; Semon, Forschungsreisen, III, pp. 731-798, Pls. XXX-XXXII.
- BENSLEY, B. Arthur. 1903. On the Evolution of the Australian Marsupialia. Trans. Linn. Soc. Lond., IX, part 3, pp. 83-217, Pls. v-vii.
- BOAS, J. E. G. and PAULLI, SIMON. 1908. The Elephant's Head. Studies in the Comparative Anatomy of the Organs of the Head of the Indian Elephant and other Mammals. Part I. Folio. 80 pp., 17 Pls. Jena. [Beautiful color plates, showing muscles of the head of various mammals.]
- BOND, G. 1878. Die Nasenhöhlen und der Thränennasengang der amnioten Wirbelthiere. Morph. Jahrb., V [issued 1879], pp. 62-140, Pls. VI-VIII.
- BOULENGER, G. A. 1918. Sur la place des Chéloniens dans la classification. Compt. rend. Acad. Sci., CLXVII, pp. 514-518.
- BROILI, F. 1904. Permische Stegocephalen und Reptilien aus Texas. Paläontographica, LI, Stuttgart, pp. 1-120, Pls. I-XIII. [Skull of *Seymouria*.]

- BROOM, R. 1902. On an Almost Perfect Skull of a New Primitive Theriodont (*Lycosuchus Vanderietii*). Trans. S. Afr. Phil. Soc., XIV, part 2, pp. 197-205, Pls. 1-11. [Lacrymal region.]
1909. The Skull of *Tapinocephalus*. Geol. Mag., N. S., Decade V, Vol. VI, No. 543, pp. 400-402.
1909. An Attempt to determine the Horizons of the Fossil Vertebrates of the Karroo, Ann. S. Afr. Mus., VII, Art. 4, pp. 285-289. [Faunal lists.]
1910. A Comparison of the Permian Reptiles of North America with those of South Africa. Bull. Amer. Mus. Nat. Hist., XXVIII, pp. 197-234. [Lacrymal region of *Galepus*, *Delphinognathus*, *Scylacosaurus*, *Aloposaurus*, *Scaloposaurus*, *Oudenodon*, *Cistecephalus*, *Diadectes*, *Pariotichus*, *Gymnarthrus*, *Edaphosaurus*, *Dimetrodon*.]
1910. On Tritylodon, and on the Relationships of the Multituberculata. Proc. Zool. Soc. London, October, pp. 760-768. [Lacrymal region.]
1911. On the Structure of the Skull in Cynodont Reptiles. Idem, pp. 893-925, Pl. XLVI. [Lacrymal region of cynodonts.]
1911. On some new South African Permian Reptiles. Idem, pp. 1073-1082, Pls. XLII-XLIII. [Lacrymal region of *Moschops*, Pl. XLII.]
1911. On the Affinities of *Cœolestes* (Marsupialia). Proc. Linn. Soc. N. S. W., XXXVI, part 2, pp. 315-320.
1912. On some Points in the Structure of the Dicynodont Skull. Ann. S. Afr. Mus., VII, part 5, pp. 337-351. [Lacrymal, p. 343.]
1913. Studies on the Permian temnospondylous Stegocephalians of North America. Bull. Amer. Mus. Nat. Hist., XXXII, pp. 563-595. [Lacrymal region of *Cricotus*, *Eryops*, *Trimerorhachis*, *Zatrachys*.]
1913. On the Gorgonopsia, a Suborder of the Mammal-like Reptiles. Proc. Zool. Soc. London, pp. 225-230, Pls. xxxvi-xxxvii. [Lacrymal region of *Scylacops*.]
1913. On the South African Pseudosuchian *Euparkeria* and allied genera. Idem, pp. 619-633, Pls. LXXV-LXXIX. [Lacrymal region.]
1913. On Some New Genera and Species of Dicynodont Reptiles, with Notes on a few others. Bull. Amer. Mus. Nat. Hist., XXXII, pp. 441-457. [Lacrymal region, especially of *D. moschops*.]
1913. On the Cotylosaurian Genus *Pantylus* Cope. Idem, pp. 527-532. [Skull pattern.]
1913. On the Structure and Affinities of *Bolosaurus*. Idem, XXXII, pp. 509-516. [Lacrymal region.]
1913. On Some New Carnivorous Therapsids. Idem, XXXII, pp. 557-561. [*Ictidorhinus*, skull.]
1914. Croonian Lecture: On the Origin of Mammals. Philos. Trans. Roy. Soc. London, (B) CCVI, pp. 1-48, Pls. 1-vii. [Lacrymal region shown in sections of therapsid skulls on Pl. v.]
1914. Some Points in the Structure of the Diadectid Skull. Bull. Amer. Mus. Nat. Hist., XXXIII, pp. 109-114. [Lacrymal region of *Diadectes*.]
1914. On the Structure and Affinities of the Multituberculates. Idem, pp. 115-134. [Lacrymal region of *Polymastodon*.]

1914. A Further Comparison of the South African Dinocephalians with the American Pelycosaur. Idem, pp. 135-141.
1915. Catalogue of Types and Figured Specimens of Fossil Vertebrates in The American Museum of Natural History, II.—Permian, Triassic and Jurassic Reptiles of South Africa. Idem, XXV, part 2, pp. 105-164. [Horizons of Karroo series, skull patterns of *Galepus*, *Aloposaurus*, *Dicynodon ictidops*, *D. moschops*, *Bauria*, *Sesamodon*.]
1915. The Triassic Stegocephalians *Brachyops*, *Bothriceps*, and *Lydekkerina*, gen. nov. Proc. Zool. Soc. London, pp. 363-368.
- BROWN, J. B. 1905. The Osteology of *Champsosaurus* Cope. Mem. Amer. Mus. Nat. Hist., IX, part 1, pp. 1-26. [Skull pattern.]
1912. A Crested Dinosaur from the Edmonton Cretaceous. Bull. Amer. Mus. Nat. Hist., XXXI, pp. 131-136. [Skull pattern of *Saurolophus*.]
1914. A Complete Skull of *Monoclonius*, from the Belly River Cretaceous of Alberta. Idem, XXXIII, pp. 549-558. [Skull pattern.]
1914. *Corythosaurus casuarius*, a New Crested Dinosaur from the Belly River Cretaceous, with Provisional Classification of the Family Trachodontidae. Idem, pp. 559-565. [Skull pattern, Pl. xli.]
1916. A New Crested Trachodont Dinosaur, *Prosaurolopus maximus*. Idem, XXXV, pp. 701-708. [Skull pattern.]
- BURCKHARDT, R. 1900. *Hyperodapedon gordonii*. Geol. Mag., N. S., Decade IV, VII, pp. 486-492 and 529-535. [Skull pattern.]
- CASE, E. C. 1907. Revision of the Pelycosauria of North America. Carnegie Institution of Washington, Publication No. 55, pp. 1-176, Pls. i-xxxv. [Classification, group characters.]
1910. New or Little Known Reptiles and Amphibians from the Permian (?) of Texas. Bull. Amer. Mus. Nat. Hist., XXVIII, pp. 163-181. [Skull patterns of *Gymnarthrus*, *Tersomius*.]
1911. Revision of the Amphibia and Pisces of the Permian of North America. Carnegie Institution of Washington, Publication No. 146, pp. 1-178, Pls. i-xxxii. [Skull patterns: *Eryops*, pp. 92, 93; *Trimerorhachis*, p. 107; *Zatrachys*, p. 113; *Lysorophus*, p. 141; *Cricotus*, p. 145.]
1911. A Revision of the Cotylosauria of North America. Carnegie Institution of Washington. Publication No. 145, pp. 1-122, Pls. i-xiv. [Classification, group characters.]
- COPE, E. D. 1889. The Batrachia of North America. Bull. U. S. Nat. Mus., No. 34. [Lacrymal of *Gyrinophilus*, Pl. xxii, fig. 1.]
- CREDNER, H. 1881-1893. Die Stegocephalen aus dem Rothliegenden des Plauen'schen Grundes bei Dresden. Abt. a. d. Zeitschr. Deutsch. geol. Gesell., XXXIII-XLV. [Numerous skull patterns.] I. Theil. 1. Einleitung, 2. *Branchiosaurus gracilis* Cred. II. Theil. *Branchiosaurus amblystomus* Cred. III. Theil. 1. *Pelosaurus laticeps* Cred., 2. *Archegosaurus decheni* Goldf., 3. *Archegosaurus latirostris* Jord. IV. Theil. *Acanthostoma vorax* Cred. V. Theil. *Melanerpeton pulcherrimum* Fr., *Pelosaurus laticeps* Cred. VI. Theil. Die Entwicklungsgeschichte von *Branchiosaurus amblystomus* Cred. VIII. Theil. *Palæohatteria longicauda* Cred. IX. Theil. *Hylonomus geinitzi* Cred., *Petrobates trunc-*

catus Cred., *Discosaurus permianus* Cred. X. Theil. *Sclerocephalus labyrinthicus*.

1891. Die Urvierfüßler (Eotetrapoda) des Sächsischen Rothliegenden. Sonder-Abd. a. d. Naturwiss. Wochenschr., pp. 1-52.

CUNNINGHAM, C. J. 1903. Text-book of Anatomy. New York. Pp. xxix+1309. [References to lacrymal duct, etc.]

CUVIER, G., AND VALENCIENNES. 1828. Histoire naturelle des Poissons, I, xvi+573 pp., Pls. I-VIII. Paris. [Early history of research on comparative anatomy of the skull of vertebrates.]

CUVIER, G., AND LAURILLARD, C. L. (no date). Anatomie Comparée. Recueil de Planches de Myologie. 340 plates in folio. Paris. [Facial muscles, etc.]

DEDERER, PAULINE H. 1909. Comparison of *Cænolestes* with Polyprotodonta and Diprotodonta. Amer. Naturalist, XLIII, pp. 614-618. [Affinities.]

DOLLO, M. L. 1883. Quatrième Note sur les Dinosauriens de Bernissart. Bull. Mus. Roy. d'Hist. Nat. Belgique, II, pp. 223-248, Pls. ix-x. [Skull of *Iguanodon*, temporal fenestræ of dinosaurs.]

DOUTHITT, H. 1917. The Structure and Relationships of *Diplocaulus*. Contrib. from Walker Mus., II, No. 1. [Skull pattern.]

ELLIOTT, D. G. 1904. The Land and Sea Mammals of Middle America and the West Indies. Pub. Field Col. Mus., Zool. Ser., IV, parts 1 and 2. [Skulls of mammals, many showing sutural pattern.]

1912. A Review of the Primates. Monographs of the Amer. Mus. Nat. Hist., I-III. [Taxonomy; skulls.]

EMBLETON, D. AND ATTHEY, T. 1874. On the Skull and some other Bones of *Loxomma allmani*. Ann. Mag. Nat. Hist., (4) XIV, pp. 38-63, Pls. iv-vi. [Lacrymal region, Pl. iv.]

FLOWER, W. H. 1866. Description of the Skeleton of *Inia geoffrensis* and of the Skull of *Pontoporia blainvillii*, with Remarks on the Systematic Position of these Animals in the Order Cetacea. Trans. Zool. Soc. London, VI, part 3, pp. 87-116, Pls. xxv-xxviii. [Lacrymal region of Cetacea, its taxonomic value.]

FLOWER, W. H. AND LYDEKKER, R. 1891. An Introduction to the Study of Mammals Living and Extinct. London.

FRAAS, E. 1889. Die Labyrinthodonten der Schwäbischen Trias. Palæontographica, XXXVI, pp. 1-158, Pls. i-xvii. [Numerous skull patterns.]

1904. Neue Zeuglodonten aus dem unteren Mittel-eocæn vom Mokattam bei Cairo. Mitth. a. d. König. Nat.-Cabinet in Stuttgart, No. 27, pp. 1-24, Pls. x-xiii. [*Protocetus atavus*.]

1902. Meer-Crocodylier (Thalattosuchia) des oberen Jura unter specieller Berücksichtigung von *Dacosaurus* und *Geosaurus*. Palæontographica, XLIX.

FRITSCH, ANT. 1883-1889. Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. I, II. Prag. [Numerous skull patterns; taxonomy.]

GAUPP, E. 1898. Zur Entwicklungsgeschichte des Eidechschädels. Berichte der Naturforsch. Gesellsch. zu Freiburg i. B., X, part 3, pp. 302-316. [Doubts homology of sauropsid "lacrimale."]

1910. Das Lacrimale des Menschen und der Säuger und seine morphologische Bedeutung. *Abd. Anat. Anz.*, XXXVI, Nos. 21, 22, pp. 529-555.
1913. Die Reichertsche Theorie (Hammer-, Amboss-, und Kieferfrage). *Arch. f. Anat. u. Entw.*, Jahrg. 1912. Supplement Band.
- GEGENBAUR, C. 1882. Ueber die Pars facialis des Lacrymale des Menschen. *Morphol. Jahrb.*, LXX, pp. 173-176.
- GIDLEY, J. W. 1912. The Lagomorphs an Independent Order. *Science*, N. S., XXXVI, No. 922, pp. 285-286.
1919. Significance of divergence of the first digit in the primitive mammalian foot. *Journ. Washington Acad. Sci.*, IX, pp. 273-280.
- GILMORE, C. W. 1909. Osteology of the Jurassic Reptile *Camplosaurus*, with a Revision of the Species of the Genus, and Descriptions of Two New Species. *Proc. U. S. Nat. Mus.*, XXXVI, pp. 197-332, Pls. vi-xx. [Skull pattern.]
1914. Osteology of the Armored Dinosauria in the United States National Museum, with Special Reference to the Genus *Stegosaurus*. *Bull.* 89, U. S. Nat. Mus., pp. 1-136, Pls. i-xxxvi. [Skull pattern.]
1917. *Brachyceratops*, a Ceratopsian Dinosaur from the Two Medicine Formation of Montana. *U. S. Geol. Surv.*, Prof. Paper 103, pp. 1-45. [Skull pattern.]
- GOODRICH, E. S. 1909. A Treatise on Zoology. Part IX. Vertebrata Craniata (First Fascicle: Cyclostomes and Fishes). Edited by Sir Ray Lankester. [Numerous skull patterns of recent and fossil fishes.]
1919. Restorations of the Head of *Osteolepis*. *Journ. Linn. Soc. London, Zool.*, XXXIV, pp. 181-188.
- GREGORY, W. K. 1910. The Orders of Mammals. *Bull. Amer. Mus. Nat. Hist.*, XXVII, pp. 1-524. [Phylogenetic relationships.]
1913. Homology of the "Lacrima" and of the "Alisphenoid" in Recent and Fossil Reptiles. *Bull. Geol. Soc. Amer.*, XXIV, pp. 241-246.
1913. Critique of Recent Work on the Morphology of the Vertebrate Skull, especially in relation to the Origin of Mammals. *Journ. Morph.*, XXIV, No. 1, pp. 1-42. [Lacrymal, pp. 3, 4.]
1915. Present Status of the Problem of the Origin of the Tetrapoda. *Ann. N. Y. Acad. Sci.*, XXVI, pp. 317-383. [Lacrymal region of Rhipidistii; comparison with stegocephs.]
1915. I. On the Relationships of the Eocene Lemur *Notharctus* to the Adapidae and to other Primates. II. On the Classification and Phylogeny of the Lemuroidea. *Bull. Geol. Soc. Amer.*, XXVI, pp. 419-446.
1916. Studies on the Evolution of the Primates. Part I. The Cope-Osborn "Theory of Trituberculy" and the Ancestral Molar Patterns of the Primates. *Bull. Amer. Mus. Nat. Hist.*, XXXV, pp. 239-355.
1917. The Coal Measures of North America. *Amer. Naturalist*, LI, pp. 311-320. [Review and critique of Moodie, 1916.]
1920. The Structure and Relations of *Notharctus*, an American Eocene Primate. *Mem. Amer. Mus. Nat. Hist.*, (N. S.) VII, part 2, pp. 49-243.
- GREGORY, W. K., AND ADAMS, L. A. 1915. The Temporal Fossæ of Vertebrates in relation to the Jaw Muscles. *Science*, N. S., XLI, pp. 763-765.
- HATCHER, J. B., MARSH, O. C., LULL, R. S. 1907. The Ceratopsia. *Monographs of the U. S. Geol. Surv.*, XLIX. [Skull patterns.]

- HAUGHTON, S. H. 1915. Investigations in South African Fossil Reptiles and Amphibia. 1. On a New Species of *Trematosaurus* (*T. Sobeyi*). Ann. S. Afr. Mus., XII, part 2, pp. 4-54. [Skull pattern; cross-section through lacrymal region.]
1918. Investigations in South African Fossil Reptiles and Amphibia. 2. Some New Carnivorous Therapsida, with Notes upon the Brain-case in Certain Species. Ann. S. Afr. Mus., XII, part 6, pp. 175-216. [Skull patterns of *Alopecognathus*, *Whaitsia*; lacrymal of *Cynosuchus*.]
1919. A Review of the Reptilian Fauna of the Karroo System of South Africa. Trans. Geol. Soc. S. Afr., XXII, pp. 1-25. [Patterns of skulls, taxonomy; faunal sequence of Karroo System.]
- HILZHEIMER, M. 1910. Zur systematischen Bedeutung des Tränenbeines. Zool. Anz., XXXVI, pp. 42-47. [Criticism of Knotterus-Meyer.]
- HOFFMAN, B. 1882. Die Thränenwege der Vögel und Reptilien. Zeitschr. f. Naturwiss., (4) I, pp. 375-410.
- HOLLAND, W. J. AND PETERSON, O. A. 1914. The Osteology of the Chalicotheroidea. Mem. Carnegie Mus., III, No. 2, pp. 189-406, Pls. XLVIII-LXXVII. [Lacrymal region.]
- HOWES, G. B., AND SWINNERTON, H. H. 1901. On the Development of the Skeleton of the Tuatera, *Sphenodon punctatus*. Trans. Zool. Soc. London, XVI, part 1, pp. 1-80, Pls. I-VI. [Lacrymal region.]
- HUENE, F. VON, 1910. Ueber einen echten Rhynchocephalen aus der Trias von Elgin, *Brachyrhinodon Tylori*. Sep.-Abd. Neuen Jahrb. für Mineralogie u. s. v., II, pp. 29-62.
1910. Neubeschreibung des Permischen Stegocephalen *Dasyceps Bucklandi* (Lloyd) aus Kenilworth. Geol. u. Pal. Abhandl. (Koken), N. F., VIII, part 6, pp. 33-46. [Skull pattern.]
1914. Ueber die Zweistämmigkeit der Dinosaurier, mit Beiträgen zur Kenntnis einiger Schädel. Sep.-Abd. Neuen Jahrb. für Mineralogie u. s. v., Beil.-Bd. XXXVII, pp. 577-589, Pls. VII-XII. [Skull patterns.]
1911. Beiträge zur Kenntnis und Beurteilung der Parasuchier. Geol. u. Pal. Abhandl. (Koken), N. F., X, part 1. [Skull patterns.]
1913. The Skull Elements of the Permian Tetrapoda in the American Museum of Natural History, New York. Bull. Amer. Mus. Nat. Hist., XXXII, pp. 315-386.
1914. Beiträge zur Kenntnis des Schädels einiger Pterosaurier. Geol. u. Pal. Abhandl. (Pompeckj u. von Huene), N. F., XIII, part 1, pp. 57-65. [Skull patterns.]
1914. Beiträge zur Geschichte der Archosaurier. Geol. u. Pal. Abhandl. (Pompeckj u. von Huene), N. F., XIII, part 1. [Skull patterns.]
- JAEKEL, O. 1903. Ueber die Epiphyse und Hypophyse. Sitz.-Ber. d. Ges. Naturforsch. Freunde zu Berlin, Jahrg. 1903, Nr. 2, pp. 27-58. [Skull patterns of stegocephs and fishes.]
1903. Ueber *Ceraterpeton*, *Diceratosaurus* und *Diplocaulus*. Sep.-Abd. Neuen Jahrb. für Mineralogie u. s. v., I, pp. 109-134. [Skull patterns.]
1904. Ueber den Schädelbau der Dicynodonten. Sitz.-Ber. d. Ges. Naturforsch. Freunde zu Berlin, 11 Oct., pp. 172-188. [Prefrontal identified as lacrymal.]

1905. Ueber den Schädelbau der Nothosauriden. Sitz.-Ber. d. Ges. Naturforsch. Freunde zu Berlin, No. 2, pp. 60-84, 8 text figures. [Skull patterns of *Trematosaurus*, *Sphenodon*, *Placochelys*, *Simosaurus*, typical Nothosaurid; prefrontal identified as lacrymal.]
- 1915-1916. Die Wirbeltierfunde aus dem Keuper von Halberstadt. Paläontolog. Zeitschr., II, part 1, pp. 88-112, (1915); part 2, pp. 113-214, Pls. II-VII (1916). [Skull and skeleton of *Stegochelys* (*Triassochelys*) *dux*.]
- JONES, WOOD. 1917. The Structure of the Orbito-temporal Region of the Skull of *Lemur*. Proc. Zool. Soc. London, pp. 323-329.
- KEITH, ARTHUR. 1913. Human Embryology and Morphology. 475 pp. London. [Development of lacrymal duct, etc.]
- KERNAN, J. D. 1918. The Skull of *Ziphius cavirostris*. Bull. Amer. Mus. Nat. Hist., XXXVIII, pp. 349-394.
- KINGSLEY, J. S. 1912. Comparative Anatomy of Vertebrates. Philadelphia. [References to lacrymal gland, etc.]
- KNOTTERNUS-MEYER, T. 1907. Ueber das Tränenbein der Huftiere. Archiv für Naturgesch., XXXVII, part 1, pp. 1-152, Pls. I-V. [Classification based on characters of lacrymal.]
- KOBER, J. 1880. Vergleichend-anatomische Beiträge zur Geschichte des Thränenbeines. Jahreshefte d. Ver. f. vaterländ. Naturk. in Württemberg, Stuttgart, pp. 118-154.
- LAMBE, L. M. 1913. A New Genus and Species of Ceratopsia from the Belly River Formation of Alberta. Ottawa Naturalist, XXVII, pp. 109-116, Pls. x-xii. [Skull patterns of Ceratopsia.]
1914. On *Gryposaurus notabilis*, a New Genus and Species of Trachodont Dinosaur from the Belly River Formation of Alberta, with a Description of the Skull of *Chasmosaurus belli*. Ottawa Naturalist, XXVII, pp. 145-155, Pls. xviii-xx. [Skull patterns.]
1914. On a New Genus and Species of Carnivorous Dinosaur from the Belly River Formation of Alberta, with a Description of the Skull of *Stephanosaurus marginatus* from the Same Horizon. Ottawa Naturalist, XXVIII, pp. 13-20, Pl. I. [Skull patterns.]
1915. On *Eoceratops canadensis*, Gen. Nov., with Remarks on Other Genera of Cretaceous Horned Dinosaurs. Mus. Bull. No. 12, Geol. Ser., No. 24, pp. 1-25, Pls. I-XI, Ottawa. [Skull patterns.]
- LANKESTER, E. R. 1901. On the Affinities of *Æluropus melanoleucus*, A. Milne-Edwards. Trans. Linn. Soc. London, (2) VIII, pp. 163-172, Pls. xviii-xx. [Skull.]
- LE DOUBLE, A. F. 1900. Essai sur la Morphogénie et les Variations du Lacrymal et des Osselets Péri-Lacrymaux de l'Homme. Bibliographie Anatomique, VIII, part 3, pp. 109-182. Paris, Nancy.
- LORTET, L. 1892. Les Reptiles Fossiles du Bassin du Rhône. Ext. Arch. Mus. Hist. Nat. Lyon, V, pp. 1-139, Pls. I-XII. [Skull patterns of *Sauranodon*, *Pleurosaurus*, *Alligatorellus*.]
- MCGREGOR, J. H. 1906. The Phytosauria, with Especial Reference to *Mystriosuchus* and *Rhytidodon*. Mem. Amer. Mus. Nat. Hist., IX, part 2, pp. 30-101, Pls. VI-XI. [Skull patterns of Phytosaurs.]

- MAJOR, C. I. FORSYTH. 1901. On some Characters of the Skull in the Lemurs and Monkeys. *Proc. Zool. Soc. London*, Feb. 19, pp. 129-153, Pls. xi-xiii. [Skull patterns, lacrymal region.]
- MARSH, O. C. 1886. *Dinocerata*. *Monogr. U. S. Geol. Surv.*, X, pp. xviii+243, Pls. i-lv. [Lacrymal region.]
- MATTHEW, W. D. 1897. A Revision of the Puerco Fauna. *Bull. Amer. Mus. Nat. Hist.*, XXII, pp. 259-323. [Systematic and phyletic relations.]
1904. The Arboreal Ancestry of the Mammalia. *Amer. Naturalist*, XXXVIII, Nos. 455-456, pp. 811-818.
1909. The Carnivora and Insectivora of the Bridger Basin, Middle Eocene. *Mem. Amer. Mus. Nat. Hist.*, IX, part 6, pp. 293-567, Pls. xliii-liv. [Lacrymal region of *Vulpavus*, *Limnocyon*, *Thinocyon*, *Harpagolestes*, *Hyopsodus*; classification of Creodonta.]
1909. Observations upon the Genus *Ancodon*. *Bull. Amer. Mus. Nat. Hist.*, XXVI, pp. 1-7.
1910. On the Skull of *Apternodus* and the Skeleton of a new Artiodactyl. *Idem*, XXVIII, pp. 33-42.
1910. On the Osteology and Relationships of *Paramys*, and the Affinities of the Ischyromyidae. *Idem*, XXVIII, pp. 43-71. [Skull patterns.]
1913. A Zalambdodont Insectivore from the Basal Eocene. *Idem*, XXXII, pp. 307-314.
1916. A Marsupial from the Belly River Cretaceous . . . *Idem*, XXXV, pp. 477-560. [Affinities and classification.]
1917. A Paleocene Bat. *Idem*, XXXVII, pp. 569-571.
1917. The Dentition of *Nothodectes*. *Idem*, XXXVII, pp. 831-839.
- MATTHEW, W. D. AND GRANGER W. 1915. A Revision of the Lower Eocene Wasatch and Wind River Faunas. Part I. Order Feræ (Carnivora), Suborder Creodonta. *Bull. Amer. Mus. Nat. Hist.*, XXXIV, pp. 1-103.
1915. Part III. Order Condylarthra. *Idem*, XXXIV, pp. 329-361.
1915. Part IV. Entelonychia, Primates, Insectivora (Part). *Idem*, XXXIV, pp. 429-483.
1918. Part VI. Insectivora (cont.), Glires, Edentata. *Idem*, XXXVIII, pp. 565-643.
- MECKEL, J. F. 1824. *System der vergleichenden Anatomie*. Theil II, Abt. I, iv + 540 pp.
- MERRIAM, J. C. 1908. On Triassic Ichthyosauria, with Special Reference to the American Forms. *Mem. Univ. Calif.*, I, No. 1, pp. 1-196, Pls. i-xviii. [Skull patterns.]
- MILLER, G. S. 1918. A New River-Dolphin from China. *Smithsonian Miscellaneous Collections*, LXVIII, No. 9, pp. 1-11, Pls. i-xiii. [Skulls of Platanistidae, etc.]
- MILLER, G. S. AND GIDLEY, J. W. 1918. Synopsis of the Supergeneric Groups of Rodents. *Journ. Washington Acad. Sci.*, VIII, No. 13, pp. 431-448. [Classification.]
- MOODIE, R. L. 1908. The Lateral Line System in Extinct Amphibia. *Journ. Morph.*, XIX, No. 2, pp. 511-540. [Comparison with fishes.]
1916. The Coal Measures Amphibia of North America. *Carnegie Institution of Washington, Publication No. 238*, x+222 pp., 26 Pls. [Skull patterns.]

- NEWTON, E. T. 1888. On the Skull, Brain, and Auditory Organ of a New Species of Pterosaurian (*Scaphognathus purdoni*) from the Upper Lias near Whitby, Yorkshire. Phil. Trans. Roy. Soc. Lond., (B) CLXXIX, pp. 503-537.
- OSBORN, H. F. 1888. The Structure and Classification of the Mesozoic Mammalia. Journ. Phil. Acad. Sci., IX. No. 2, pp. 186-265.
1892. Is *Meniscotherium* a Member of the Chalicotherioidea? Amer. Naturalist, XXVI, No. 306, pp. 507-509. [Suggests that there is a presumption in favor of a genetic relationship between *Meniscotherium* and the Chalicotherioidea.]
1898. Remounted Skeleton of *Phenacodus primævus*. Comparisons with *Euprotogonia*. Bull. Amer. Mus. Nat. Hist., X, pp. 159-164, Pl. xii.
1898. The Extinct Rhinoceroses, Parts I, II. Mem. Amer. Mus. Nat. Hist., I, part 3, pp. 75-164, Pls. xii-xx. [Lacrymal region of *Leptacatherium*, *Aceratherium copei*, etc., in Pls. xiv-xvii.]
1903. The Reptilian Subclasses Diapsida and Synapsida and the Early History of the Diaptosauria. Idem, I, part 8, pp. 451-519. [Classification.]
1907. Evolution of Mammalian Molar Teeth to and from the Triangular Type. vi+250 pp. 8vo. New York.
1909. The Feeding Habits of *Mæriotherium* and *Palæomastodon*. Nature, LXXXI, No. 2074, pp. 139-140. [Affinities of these Genera.]
1910. The Age of Mammals. xvii+635 pp. 8vo. New York.
1912. Crania of *Tyrannosaurus* and *Allosaurus*, Mem. Amer. Mus. Nat. Hist., N. S., I, part 1, pp. 1-30, Pls. i-iv.
1918. Equidæ of the Oligocene, Miocene and Pliocene of North America. Iconographic Type Revision. Idem, N. S., II, part 1. [Numerous skull patterns.]
- OSBORN, H. F., AND MATTHEW, W. D. 1909. Cenozoic Mammal Horizons of Western N. America. U. S. Geol. Surv. Bull. 361, pp. 1-138. [Faunal lists.]
- OWEN, RICHARD. 1843. MS. Catalogue of the Osteological Collection in the Museum of the Royal College of Surgeons, I [issued 1853], vii+350 pp. London. [Table of Synonyms: Bones of the Vertebrata, according to their Special Homologies, pp. xxxviii-xliii.]
1846. Lectures on the Comparative Anatomy and Physiology of the Vertebrate Animals, delivered at the Royal College of Surgeons of England in 1844 and 1846. Part I. Fishes. [Homology of lacrymal bone, pp. 99, 108 (fig.) 160.]
1871. Monograph of the Fossil Mammalia of the Mesozoic Formations. The Palæontographical Society. Volume for 1870, pp. 1-116, Pls. i-iv.
- PANDER, C. H. 1860. Ueber die Saurodipteren, Dendrodonten, Glyptolepiden und Cheirolepiden des Devonischen Systems. pp. i-ix, 1-90, Pls. i-xvii. St. Peterburg.
- PARKER, T. J. 1891. Observations on the Anatomy and Development of *Apteryx*. Phil. Trans. Roy. Soc. Lond., (B) CLXXXII, pp. 25-134, Pls. i-xix. [Lacrymal region.]

1893. A Course of Instruction in Zootomy. Vertebrata. 8vo. London. [Applies term parethmoid to lateral ossification of olfactory capsule.]
- PARKER, W. K. 1869. On the Structure and Development of the Skull in the Common Fowl (*Gallus domesticus*). Phil. Trans. Roy. Soc. Lond., (B) CLIX, pp. 755-807, Pls. LXXX-LXXXVII.
1873. On the Structure and Development of the Skull in the Salmon (*Salmo salar* L.). Idem, (B) CLXIII, part 1, pp. 95-145, Pls. i-viii.
1874. On the Structure and Development of the Skull in the Pig (*Sus scrofa*). Idem, (B) CLXIV, pp. 289-336, Pls. xxviii-xxxvii.
1877. On the Structure and Development of the Skull in the Urodelous Amphibia. Part I. Idem, (B) CLXVII, part 2, pp. 529-597, Pls. xxi-xxix.
1878. On the Structure and Development of the Skull in the Common Snake (*Tropidonotus natrix*). Idem, (B) CLXIX, part 2, pp. 385-417, Pls. xxvii-xxxiii.
1882. On the Structure and Development of the Skull in Sturgeons (*Acipenser ruthenus* and *A. sturio*). Idem, (B) CLXXIII, part 1, pp. 139-185, Pls. xii-xviii.
1883. On the Structure and Development of the Skull in the Chameleons. Trans. Zool. Soc. London, XI, part 3, pp. 77-105, Pls. xv-xix.
1883. On the Structure and Development of the Skull in the Crocodilia. Idem, XI, part 9, pp. 263-310, Pls. lxii-lxxii.
1885. On the Structure and Development of the Skull in the Mammalia. Part II, Edentata; Part III, Insectivora. Phil. Trans. Roy. Soc. Lond., (B) CLXXVI, part 1, pp. 1-275, Pls. i-xxxviii.
- POLLARD, H. B. 1892. On the Anatomy and Phylogenetic Position of *Polypterus*. Zool. Jahrb. (Abt. f. Anat. u. Ontog.), V, pp. 387-423, Pls. xxvii-xxx. [Lacrymal region.]
- PYCRAFT, W. P. 1900. On the Morphology and Phylogeny of the Palæognathæ (Ratitæ and Crypturi) and Neognathæ (Carinatæ). Part II. Trans. Zool. Soc. London, XV, pp. 151-267.
- RUGE, G. 1886. Ueber die Gesichtsmuskulatur der Halbaffen. Morph. Jahrb., XI, pp. 243-315, Pls. xiv-xvi.
1897. Ueber das peripherische Gebiet des Nervus facialis bei Wirbelthieren. Festschrift für Carl Gegenbaur, III, pp. 195-348.
- SAKASIN, PAUL AND FRITZ. 1890. Zur Entwicklungsgeschichte und Anatomie der ceylonischen Blindwühle *Ichthyopsis glutinosus*. Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon in den Jahren 1884-1886. II, part 4, pp. 1-263, Pls. i-xxiv.
- SCHULTE, H. VON W. 1916. Anatomy of a Fœtus of *Balanoptera borealis*. Mem. Amer. Mus. Nat. Hist., N. S., I, part 6, pp. 398-502, Pls. xlvi-lvii. [Lacrymal region.]
1917. The Skull of *Kogia breviceps* Blainv. Bull. Amer. Mus. Nat. Hist., XXXVII, pp. 361-404.
- SCOTT, W. B. 1905. Mammalia of the Santa Cruz Beds. I. Edentata; II. Insectivora; III. Glires. Rep. Princeton Univ. Exp. to Patagonia, V, xi+499 pp., Pls. i-xxi. [Lacrymal region of ground sloths, glyptodonts.]

1910. *Litopterna* of the Santa Cruz Beds. Idem, VII, part 1, pp. 1-156, Pls. I-XX. [Lacrymal region of *Litopterna*.]
1912. *Toxodontia* of the Santa Cruz Beds. Part II. *Entelonychia* of the Santa Cruz Beds. Part III. Idem, VI, pp. 111-300, Pls. XIII-XXX. [Lacrymal region of *Toxodontia*, *Entelonychia*.]
1913. A History of Land Mammals in the Western Hemisphere. New York. xii+693 pp. [Lacrymal region of early *Camelidæ*.]
- SÉELEY, H. G. 1895. Researches on the Structure, Organization and Classification of the Fossil Reptilia. Part IX, Sec. 5. —On the Skeleton in new *Cynodontia* from the Karroo Rocks. Phil. Trans. Roy. Soc. Lond., (B) CLXXXVI, pp. 59-148. [Lacrymal region of *Cynognathus*.]
- SINCLAIR, W. J. 1901. Part III. Mammalia of the Santa Cruz Beds. Marsupialia. Rep. Princeton Univ. Exp. to Patagonia, IV. [Lacrymal region of *Borhyaena*, *Cladosictis*, *Amphiprovivera*.]
1909. *Typotheria* of the Santa Cruz Beds. Idem, VI, part I, pp. 1-110, Pls. I-XI. [Lacrymal region of *Protypotherium*, *Pachyrhinos*, etc.]
- SISSON, S. 1914. The Anatomy of the Domestic Animals. Second Edition. Philadelphia and London. [Anatomy of lacrymal region.]
- SOLLAS, I. B. J., AND W. J. 1913. A Study of the Skull of a *Dicynodon* by means of Serial Sections. Phil. Trans. Roy. Soc. Lond., (B) CCIV, pp. 201-225, Pls. XVII-XVIII. [Lacrymal region.]
1916. On the Structure of the *Dicynodont* Skull. Phil. Trans. Roy. Soc. Lond., (B) CCVII, pp. 531-539, Pls. XXXV-XXXVI. [Lacrymal region.]
- SPENCER, BALDWIN. 1900. A Description of *Wynyardia bassiana* a Fossil Marsupial from the Tertiary beds of Table Cape, Tasmania. Proc. Zool. Soc. London, November 20, pp. 776-795, Pl. XLIX. [Lacrymal region.]
- STANDING, H. F. 1908. On recently discovered Subfossil Primates from Madagascar. Trans. Zool. Soc. London, XVIII, part 2, pp. 59-177, Pls. x-xxviii. [Skulls of *Megaladapis*, *Palæopropithecus*, *Mesopropithecus*, *Archæolemur*.]
- STARKS, E. C. 1901. Synonymy of the Fish Skeleton. Proc. Wash. Acad. Sci., III, pp. 507-539, Pls. LXIII-LXV, figs. 45, 46. [Elements of the fish skull with synonymy and references.]
- STEHLIN, H. G. 1889. Ueber die Geschichte des Suiden-Gebisses. I. Teil. Abhandl. d. schweiz. palæont. Gesellsch., XXVI, pp. I-VII, 1-336. Die Säugetiere des schweizerischen Eocaens. . . . Abhandl. d. schweiz. palæont. Ges.
1906. IV. Teil, idem, XXXIII, pp. 597-690, Taf. Dichobune, etc. [Lacrymal region of *Dichobune*, pp. 604-605.]
1912. VII. Teil, I Hälfte *Adapis*. [Lacrymal region, pp. 1192-1195, 1196, 1197, 1248, 1249, 1251, 1252.]
1916. VII. Teil, II Hälfte. [Lacrymal region of *Necrolemur*, pp. 1341, 1343, 1344.]
- THÉVENIN, A. 1910. Les Plus Anciens Quadrupèdes de France. Ann. de Paléontologie (Boule), V, pp. 1-64, Pls. I-IX. [Skull patterns.]
- TÜFFERS, PAUL. 1913. Die Entwicklung des Nasalen Endes des Tränennasenganges bei einigen Säugetieren. Anatom. Hefte (Merkel u. Bonnet), I. Abt., pp. 147, 148; XLIX, pp. 401-439.

- WATSON, D. M. S. 1911. The skull of *Diademodon* with Notes on those of some other Cynodonts. *Ann. Mag. Nat. Hist.*, (8) VIII, pp. 293-330.
1913. Further Notes on the Skull, Brain, and Organs of Special Sense of *Diademodon*. Idem, (8) XII, pp. 217-228.
1913. *Micropholis stowii*, Huxley, a Temnospondylous Amphibian from South Africa. *Geol. Mag., N. S.*, (V) X, pp. 340-346. [Skull pattern, naso-lacrymal duct.]
1913. The Beaufort Beds of the Karroo System of South Africa. *Geol. Mag., N. S.*, (V) X, pp. 388-393.
1913. *Batrachiderpeton lineatum* Hancock and Atthey, a Coal Measure Stegocephalian. Idem, pp. 949-962. [Skull pattern.]
1914. On the Skull of a Pariasaurian Reptile and on the Relationship of that Type. *Proc. Zool. Soc. London*, pp. 155-180.
1914. *Procolophon trigoniceps*, a Cotylosaurian Reptile from South Africa. *Proc. Zool. Soc. London*, II, pp. 735-746, Pls. i-iii. [Skull pattern.]
1914. The Deinocephalia, an Order of Mammal-like Reptiles. *Proc. Zool. Soc. London*, II, pp. 749-786, Pls. iv-v. [Skull patterns.]
1914. *Eunotosaurus africanus* Seeley and the Ancestry of the Chelonia. *Proc. Zool. Soc. London*, pp. 1011-1020. [Relationships with Chelonia.]
1914. The Zones of the Beaufort Beds of the Karroo System in South Africa. *Geol. Mag., N. S.*, (VI) I, pp. 203-208.
1914. Notes on *Varanosaurus acutirostris*, Broili. *Ann. Mag. Nat. Hist.*, (8) XIII, pp. 297-310. [Skull pattern.]
1914. *Pleurosaurus* and the Homologies of the Bones of the Temporal Region of the Lizard's Skull. *Ann. Mag. Nat. Hist.*, (8) XIV, pp. 84-85, Pl. vi.
1916. The Monotreme Skull: A Contribution to Mammalian Morphogenesis. *Phil. Trans. Roy. Soc. London*, (B) CCVII, pp. 311-374, Pls. xxiii-xxv.
1916. Reconstructions of the Skulls of three Pelycosaurus in The American Museum of Natural History. *Bull. Amer. Mus. Nat. Hist.*, XXXII, pp. 637-648.
1917. Sketch Classification of the Pre-Jurassic Tetrapod Vertebrates. *Proc. Zool. Soc. London*, pp. 167-186.
1919. The Structure, Evolution and Origin of the Amphibia.—The "Orders" Rachitomi and Stereospondyli. *Phil. Trans. Roy. Soc. London*, (B) CCIX, pp. 1-73.
1919. On *Seymouria*, the most primitive known Reptile, *Proc. Zool. Soc. London*, pp. 267-301. [Discussion of taxonomic relationships of *Seymouria* and of other reptiles, relationships of reptiles with amphibians, etc.]
- WATSON, D. M. S., AND DAY, H. 1916. Notes on Some Palæozoic Fishes. *Mem. and Proc. Manchester Lit. and Phil. Soc.*, LX, part I, No. 2, pp. 1-52, Pls. i-iii. [Skull patterns Dipnoi and Rhinidistii.]
- WEBER, M. 1904. *Die Säugetiere*. . . . Jena, iv+865 pp.
- WIEDERSHEIM, R. 1877. *Das Kopfskelet der Urodelen*. *Morph. Jahrb.*, III, pp. 352-448, Pls. xix-xxiii.
1879. *Die Anatomie der Gymnophionen*. 4to, Jena, pp. 1-101, Pls. i-ix. [Skull patterns.]

1886. Lehrbuch der vergleichenden Anatomie der Wirbeltheire auf Grundlage der Entwicklungsgeschichte bearbeitet. Zweite Auflage, Jena.
- WILLISTON, S. W. 1902. On the Skull of *Nyctodactylus*, an Upper Cretaceous Pterodactyl. *Journ. Geol.*, X, No. 5, pp. 520-531.
1908. The *Cotylosauria*. Idem, XVI, No. 2, pp. 139-148. [Skull pattern of *Labidosaurus*.]
1909. New or Little Known Permian Vertebrates. *Trematops*, New Genus. Idem, XVII, No. 7, pp. 636-658. [Skull pattern.]
1911. A New Family of Reptiles from the Permian of New Mexico. *Amer. Journ. Sci.*, XXXI, pp. 377-398. [*Limnoscelis*, skull pattern.]
1911. American Permian Vertebrates. Chicago, pp. 1-145, Pls. I-XXXVIII. [Lacrymal region of *Varanosaurus*, p. 87.]
1914. *Broiliellus*, a new Genus of Amphibians from the Permian of Texas. *Journ. Geol.*, XXII, No. 1, pp. 49-56. [Skull pattern.]
1914. The Osteology of Some American Permian Vertebrates. Idem, No. 4. Contrib. from Walker Mus., I, No. 8. [*Aræoscelis*, pp. 364-403; *Palæohatteria*, 396; *Kadaliosaurus*, 396; *Proterosaurus*, 394; skull of *Casea*, 403-407. Genetic Relations.]
1915. *Trimerorhachis*, a Permian Temnospondyl Amphibian. Idem, XXIII, No. 3, pp. 246-255. [Skull pattern.]
1915. A New Genus and Species of American Theromorpha-*Mycterosaurus longiceps*. Idem, XXIII, No. 6, pp. 554-558. [Skull pattern.]
1916. The Osteology of Some American Permian Vertebrates. Idem, XXIV, No. 4, Contrib. from Walker Mus., I, No. 9. [*Pantylus*, skull pattern, pp. 165-236.]
1916. Synopsis of the American Permo-carboniferous Tetrapoda. Idem, [skull pattern of *Broiliellus*, Fig. 44; *Trimerorhachis*, Fig. 46; *Diplocaulus*, Fig. 52; *Lysorophus*, p. 211; *Seymouria*, Figs. 60, 61; *Cardiocephalus*, Fig. 63; *Labidosaurus*, Fig. 65; *Mycterosaurus*, Fig. 83.]
1917. The Phylogeny and Classification of Reptiles. Idem, XXV, No. 5, pp. 411-421.
1918. The Osteology of Some American Permian Vertebrates, III. Contrib. from Walker Mus., II, No. 4, pp. 75-112, Pls. III, IV. [Skull pattern of *Naosaurus*, Fig. 11, p. 99.]
- WIMAN, C. 1917. Ueber die Stegocephalen *Tertrema* und *Lonchorhynchus*. *Bull. Geol. Instit. of Upsala*, XIV. [Skull patterns.]
- WINDLE, B. C. A. AND PARSONS, F. G. 1897. On the Myology of the Terrestrial Carnivora, Part I. *Proc. Zool. Soc. London*, pp. 370-409. [Facial muscles, pp. 373-376.]
1901. On the Muscles of the Ungulata, Part I. Idem, pp. 656-704. [Facial muscles, pp. 660-663.]
- WORTMAN, J. L. 1897. The Ganodonta and their Relationship to the Edentata. *Bull. Amer. Mus. Nat. Hist.*, IX, pp. 59-110.
- 1901-1902. Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum. Part I. Carnivora. *Amer. Journ. Sci.*, XI-XIV, pp. 1-145. [Skull patterns of Mesonychidæ.]
- 1903-1904. Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum. Part II. Primates. Idem, XV-XVII, pp. 147-250. [Discussion of lacrymal region.]

1920. On some hitherto unrecognized Reptilian Characters in the Skull of the Insectivore and other Mammals. *Proc. U. S. Nat. Mus.*, LVII, pp. 1-52. [Records presence of elements homologized with reptilian "prefrontal," "post frontal" etc.]

ZITTEL, K. A. VON. 1911. *Grundzüge der Paläontologie (Paläozoologie)*, II Abt.: Vertebrata.

ADDENDUM

Watson (1913) on the Naso-lachrymal Duct in *Nythosaurus* and *Diademodon*.

In his second paper on the skull of *Diademodon* Watson (1913, p. 224) describes the naso-lachrymal duct of *Nythosaurus* and of *Diademodon* in the following important passage, which I unfortunately overlooked until quite recently:

Another feature extremely clearly shown by these two iron-stone casts is the course of the naso-lachrymal duct. This opens into the orbit by two foramina in the lachrymal bone, leading into canals, which soon unite and then travel forward still in the lachrymal bone until they open into the nasal cavity on the inner side of the maxilla. These relations are so very similar to those existing in *Perameles* between the duct and the lachrymal bone as to leave no doubt that the bone in Cynodonts is homologous with that of the mammal. It is, however, the lower of the two bones usually called lachrymal and prefrontal, and as the Cynodonts are certainly more nearly allied to the mammals than the lizards, it leaves no doubt that Gaupp was not justified in homologizing the reptilian prefrontal with the mammalian lachrymal. Meek, from the conditions in the Crocodile, has already controverted this view, Gaupp having no doubt been misled by the great reduction of the true lachrymal in the types studied by him.

Notwithstanding this decisive evidence in favor of the long established identification of the reptilian lacrymal as homologous with that of mammals, von Huene, Wiman and Abel continue to follow Gaupp's erroneous identification of the reptilian prefrontal with the mammalian lacrymal.

**Article III.—STUDIES IN COMPARATIVE MYOLOGY AND
OSTEOLOGY, NO. V.—ON THE ANATOMY OF THE PRE-
ORBITAL FOSSÆ OF EQUIDÆ AND OTHER
UNGULATES**

By W. K. GREGORY

PLATE XVIII

CONTENTS

	PAGE
INTRODUCTION.....	265
THE PREORBITAL FOSSÆ OF RHYNCHOCYON AND THE SUIDÆ.....	266
THE LOWER OR "MALAR" FOSSA OF THE EQUIDÆ.....	269
THE UPPER OR "LACRYMAL" FOSSA OF THE EQUIDÆ.....	270
The "Lacrymal" Fossa not a "Larmier".....	270
The "Lacrymal" Fossa not for the Maxillo-labialis Superior Muscle.....	271
The "Lacrymal" Fossa not for the Naso-labialis Muscle.....	271
The "Lacrymal" Fossa not for a Dorsal Extension of the Buccinator.....	273
RELATIONS OF THE PREORBITAL FOSSÆ TO UNDERLYING SINUSES, TO THE DENTAL ALVEOLI AND TO STRENGTHENING RIDGES AND EMINENCES..	274
THE NASAL DIVERTICULA OF UNGULATES AND THEIR RELATIONS WITH THE "LACRYMAL" FOSSA.....	275
SUMMARY AND CONCLUSIONS.....	282
REFERENCES TO LITERATURE.....	283

INTRODUCTION

In certain extinct Equidæ (Pl. XVIII) there are two fossæ on the side of the bony face in front of the orbit. The upper one of these is partly on the lacrymal bone and has therefore been called the "lacrymal fossa" by Gidley (1906) and Osborn (1918). The lower one, when present, is located partly on the anterior part of the malar and is therefore termed by Gidley and Osborn the "malar fossa." Each of these fossæ differs widely in the genera and species of fossil Equidæ, and have therefore been used by systematists as generic and specific characters.

Concerning the function of the upper, or "lacrymal," fossa, the older interpretation was that of Gaudry (1862), Lydekker (1884, pp. 13, 14) and others, who thought that it served to hold a "larmier" or facial gland, similar to that of ruminant artiodactyls. Another explanation was that of Prof. Studer (1911, p. 109), who held that the "pre-orbital groove" of certain extinct hippoids was essentially similar to

that of mammals having a proboscis, and that the groove served to lodge the levator muscles of a proboscis, with which he supposed *Onohippidium* and *Hipparion proboscideum* to have been provided. A third explanation was tentatively considered by Professor Osborn, who in conversation with me suggested that the preorbital groove might have lodged a backward extension of the nasal diverticulum, a structure which is vestigial or reduced in modern Equidæ. Professor Osborn also invited me to investigate the subject and generously placed at my disposal the great collection of recent and fossil horses in this Museum. A fourth explanation, advanced by Dr. W. D. Matthew, was that the development of the preorbital fossæ was correlated with the upraising of stiffening ridges and eminences above and below the fossæ and with the hollowing out of the parts not so strengthened.

The main conclusions at which I have arrived may be briefly summarized as follows:

(1) The upper, or "lacrymal," fossa probably did not lodge a "larmier" or facial gland, nor did it serve for the muscles of the snout; nor did *Onohippidium* and *Hipparion proboscideum* have a proboscis or anything like it. On the contrary, the fossa in question probably did lodge a greatly enlarged nasal diverticulum as suggested by Professor Osborn.

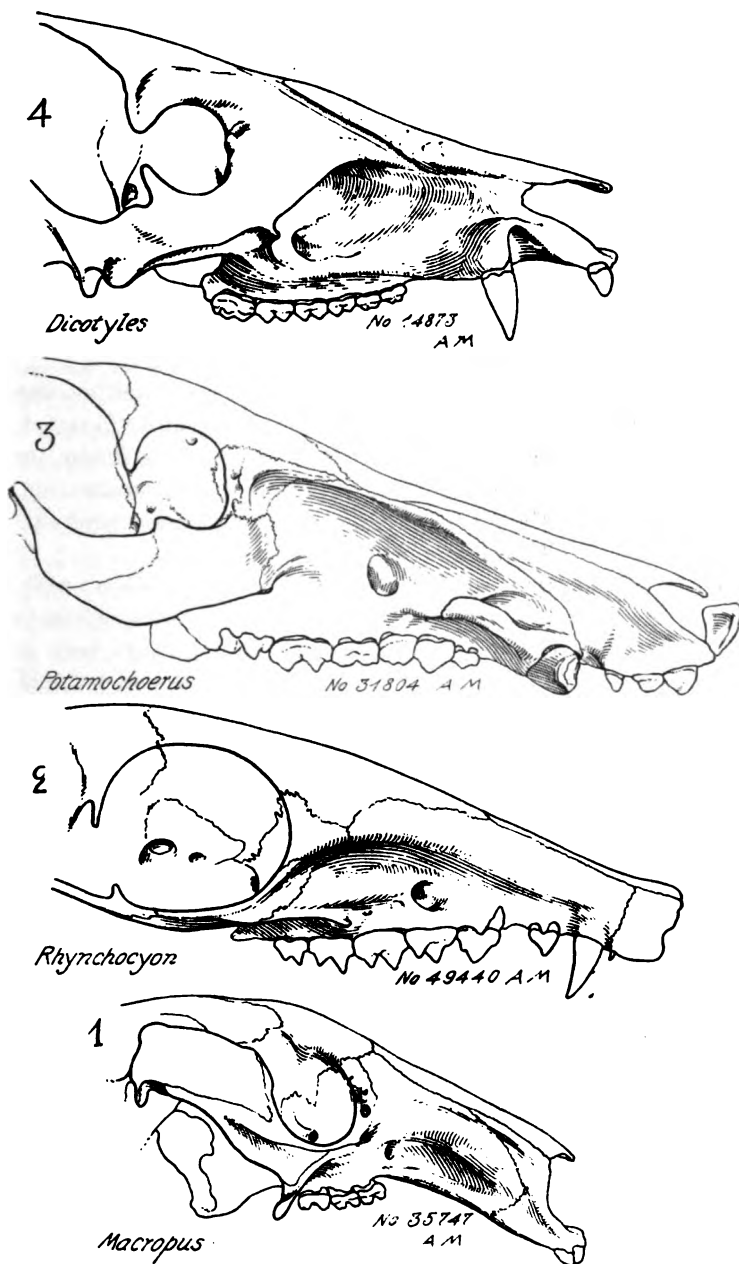
(2) The lower or "malar" fossa, when present, lodged the proximal end of the "maxillo-labialis superior," or levator labii superioris, muscle.

(3) The existence of these and of similarly placed fossæ in other ungulates is also partly conditioned by the further subsidence of certain depressed areas lying between areas or tracts that have been upraised or strengthened to resist stresses and partly by the lack of support beneath the subsided areas, due to the presence of great underlying sinuses in the maxilla, malar, and lacrymal bones.

Mr. S. H. Chubb and Mr. Erwin S. Christman have taken great interest in the present investigation and have assisted greatly by their critical comments and observations. The illustrations are by Mr. Christman.

THE PREORBITAL FOSSÆ OF *RHYNCHOCYON* AND THE SUIDÆ

Early in the course of the present investigation I thought that the preorbital fossa of *Rhynchocyon* (Fig. 2) and the Suidæ (e. g., *Potamocharus*, Fig. 3) was more or less analogous with that of such extinct Equidæ as *Merychippus* (Pl. XVIII) and that a study of its function in the first two might give a clue to its function in the latter. In *Rhynchocyon* and the Suidæ (Fig. 5) the fossa in question lodges the muscles of the



Figs. 1-4. Preorbital fossae of various mammals.

1. *Macropus*. Skull of a very old kangaroo, with a deep fossa in front of the infraorbital canal. This fossa lodges a part of the buccinator muscle which also extends up on the side of the face beneath the superficial muscles. (Von Boas and Paulli, 1908, Pl. xiii.)
2. *Rhynchocyon*. The preorbital fossa lodges the muscles of the long snout.
3. *Potamochoerus*. The preorbital fossa, for the muscles of the snout, is sharply defined above and leads directly forward toward the protruding snout.
4. *Dicotyles*. The preorbital fossa and snout muscles are much shorter anteroposteriorly than in *Potamochoerus*.

snout (the "maxillo-labialis superior" and "maxillo-labialis inferior") and the inference was that the preorbital fossæ of Equidæ probably also lodged homologous muscles. I afterward found that Professor Studer (1911, pp. 199, 200), arguing from similar grounds, had reached a similar conclusion with regard to the preorbital fossæ of *Hipparion proboscideum* and *Onohippidium*. Nevertheless, I was later compelled to reject this conclusion for the following reasons.

First, it can be shown conclusively that the fossæ in question in the Equidæ arose within the family and are not truly homologous with those of Artiodactyla, that there were no such fossæ in the primitive placental mammals of the Paleocene and Eocene, and that the Artiodactyla and Perissodactyla were not derived from a common stem family but are widely distinct orders. Hence, it is not permissible to assume that non-homologous fossæ in these two widely separated groups arising in different ways were yet filled by homologous structures.

Secondly, the preorbital fossæ in Suidæ (Figs. 3, 4), as well as in *Rhynchoryon* (Fig. 2), are associated with a tapering bony muzzle and a cylindrical protruding snout. Such characters certainly may not be assigned to *Pliohippus lullianus* (Pl. XVIII) which, although it had deep preorbital fossæ, is very close to a modern horse in the bony supports of the muzzle.

Thirdly, the preorbital fossæ in Suidæ lead forward toward the snout, whereas in the Equidæ (Pl. XVIII), when well developed, they are produced forward and downward toward the diastema between the canine and the first premolar.

Finally, as will be shown below, the conclusion that the preorbital fossæ of extinct Equidæ functioned, as in Suidæ, solely to lodge the muscles of the snout is at variance with the far more direct evidence afforded by the soft anatomy of existing Equidæ. And it is shown by experience that in all attempts to reconstruct missing parts either of a given extinct animal or in a phylogenetic scheme, the more direct evidence afforded by apparently homologous parts or conditions in closely related types outweighs in value the more indirect evidence derived from widely removed types and possibly convergent conditions.

Hence, I do not regard it as safe to pass from the known function of the preorbital fossæ of Suidæ to the unknown function of possibly non-homologous fossæ in the Equidæ, although other and more reliable evidence has convinced me that the preorbital fossæ of Suidæ are functionally analogous in part only with the lower preorbital, or "malar," fossæ of certain Equidæ. In the Suidæ the preorbital fossæ lodged both

the maxillo-labialis superior and the maxillo-labialis inferior, while in the Equidæ the latter muscle was entirely below the fossa and was attached to the anterior end of the masseteric ridge (Figs. 9, 19, and Pl. XVIII).

THE LOWER OR "MALAR" FOSSÆ OF THE EQUIDÆ

In recent horses (Figs. 9 to 12 and Pl. XVIII, *Equus*) there is, on the side of the face in front of the orbit, a muscle called the maxillo-labialis superior by von Boas and Paulli and the levator labii superioris by other authors. This runs from the side of the maxilla immediately above the masseter ridge obliquely forward and upward into a long, thin tendon which, passing the anterior tip of the nasal bones and joining its fellow of the opposite side, is prolonged forward in the midline above the nostrils and downward to the upper lip. About the middle of its course, and well behind the notch between the nasals and premaxillæ, the muscle in question passes immediately above the infraorbital canal (Pl. XVIII, *Equus caballus*). A line drawn just below the tip of the nasals, through the upper border of the infraorbital canal and continued back to the lacrymal above the masseter ridge, will always give the general course of this muscle in recent Equidæ.

In many skulls of horses, zebras, and asses preserved in the large collection made by Mr. Chubb for this Museum, there is a slight depression, or fossa, at the site of the origin of the maxillo-labialis superior (Fig. 12 and Pl. XVIII, *Equus*). In many fossil Equidæ there is a more or less well-defined fossa at this point. Sometimes, as in *Protohippus niobrarensis*, the lower, or "malar" fossa is but slightly indicated; in other specimens it is very deep (*Pliohippus lullianus*); and in still others it is barely visible (*Kalobatippus*). I conclude that, although this lower fossa is more or less variable, it always marks the site of origin of the maxillo-labialis superior, which, as shown by the whole configuration of the fore part of the skull, must have been located substantially as in modern Equidæ. (See Plate XVIII.)

Considerable difficulty was caused for a long time by the fact that in extinct Equidæ this lower fossa is often confluent with the upper or lacrymal fossa (Pl. XVIII, *Pliohippus lullianus*, *Merychippus*, *Parahippus*) and that the two together sometimes bear some resemblance to the preorbital fossa of the Suidæ and of other mammals having strongly developed muscles of the snout.

A second difficulty arose from the fact that some extinct Equidæ (*Hypohippus*, *Miohippus*) have but a single preorbital fossa, and

at first it was very difficult to determine whether this was the homologue of the upper fossa only or of both fossæ together. Comparison of these cases with that shown in *Archæohippus ultimus* indicates that in them it is only the upper, or "lacrymal," fossa which is present and that the lower fossa has not yet been formed, as in *Miohippus* and *Hypohippus*. (See Plate XVIII.)

When examined in detail, the preorbital fossæ of Equidæ differ in many particulars from those of mammals of other orders, and, as stated above, it finally seemed an unwarranted begging of the question to assume that they were occupied by homologous structures in widely different orders. It was finally realized that the safest criteria for the interpretation of fossil Equidæ were afforded by recent Equidæ and to some extent by members of other families of the same order. Comparison with recent Equidæ leaves practically no doubt that the function of the lower fossa was the lodgement of the maxillo-labialis superior; but, as this fossa is very variable among recent Equidæ in its occurrence and degree, while the muscle is constant both in occurrence and position, we may be sure that in extinct Equidæ the absence of the fossa does not imply the absence of the muscle at that point, especially since the form of the nasals and premaxillæ were extremely horse-like in all these Equidæ.

THE UPPER OR "LACRYMAL" FOSSA OF THE EQUIDÆ

THE "LACRYMAL" FOSSA NOT A "LARMIER"

Lydekker, in his description of *Hippotherium antilopinum* (1884, pp. 13, 14), describes two preorbital fossæ; the first, designated by Lydekker as "B," is homologous with the so-called "lacrymal" fossa of Osborn and the second (Lydekker's "A") is homologous with the "buccinator" fossa (Fig. 12) of the present paper.

After noting that Gaudry (1862, p. 221) had called the fossa "B" a "larmier" Lydekker says:

The smooth form of these cavities in the Perim skull (*H. antilopinum*) leaves little or no doubt that they once contained a sebaceous gland, like the 'larmier' of the deer and antelopes. In all deer and in most antelopes the larmier is single, and placed almost entirely in the lachrymal; having of course no connection with the infra-orbital foramen. In some antelopes, however (e. g., *Cephalopus maxwelli* [sic], and *C. pygmaea*)¹ a similar cavity is present in the maxilla, which sometimes coexists with the lachrymal cavity, and sometimes replaces it. "In the African waterhogs (*Potamocharus*) a naso-maxillary pit opens between the eye and the snout, rather nearer the eye."² In *Oreodon*³ there is a single cavity which is confined to the lachrymal.

¹See Owen, *Anatomy of Vertebrates*, III, p. 633.

²Owen, *op. cit.*, p. 634.

³Gaudry, *Les Enchaînements—Mam. Tert.*, p. 81, fig. 90.

These observations indicate pretty clearly that the maxillary cavities of *Hippotherium* are homologous with those of the Artiodactyla; and are very noteworthy as being one of the very few evidences among the later forms of an original connection between the artiodactyle and perissodactyle modifications of the Ungulata.

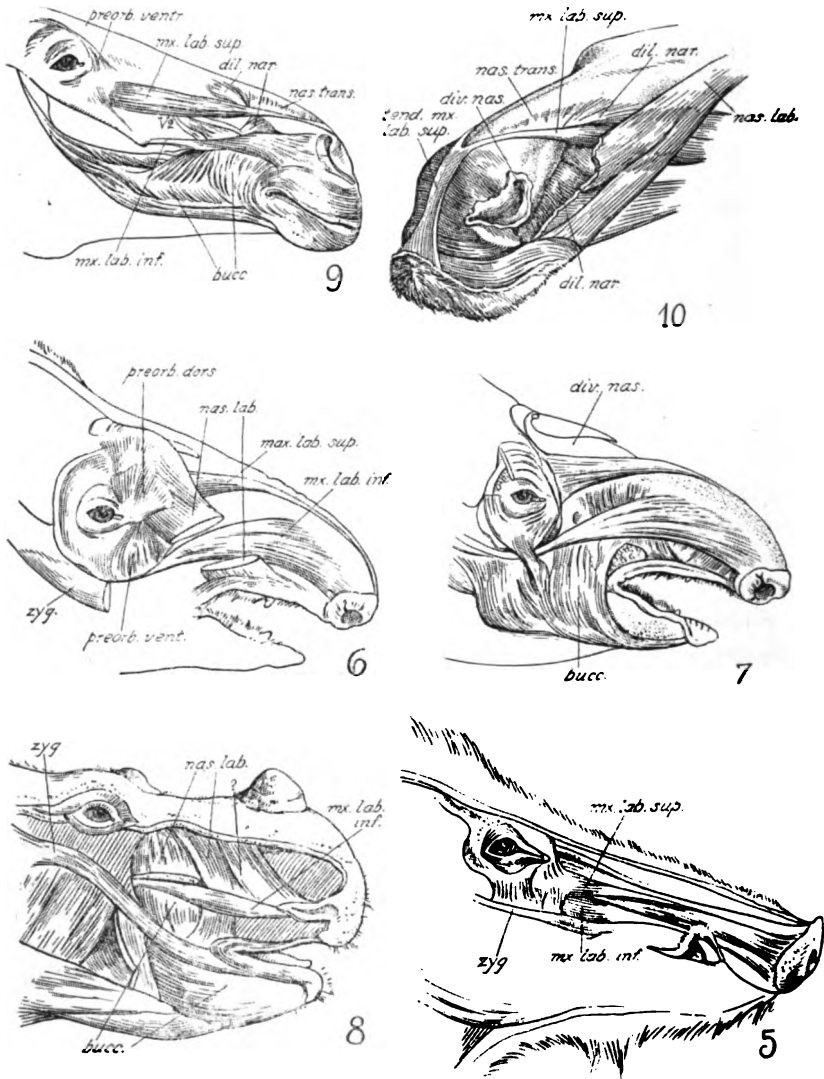
Notwithstanding these conclusions by Lydekker, I am led to believe that the "lacrymal" fossa of extinct Equidæ did not lodge a sebaceous gland like the "larmier" of the deer and antelopes. The fossa in question is extremely different in form from that which contains the "larmier" in ruminants and oreodonts, as shown in figures in my recent paper on the lacrymal region of mammals. The true "larmier" fossa is more or less circular in form and is bounded by a well-defined rim. The "lacrymal" fossa of extinct Equidæ, on the other hand, is totally different in appearance and is often continued forward and downward (Pl. XVIII) toward the buccinator fossa.

THE "LACRYMAL" FOSSA NOT FOR THE MAXILLO-LABIALIS SUPERIOR MUSCLE

The first reason for believing that the "lacrymal" fossa is not for the maxillo-labialis superior muscle is that this muscle has been pretty certainly allocated to the lower one of the two preorbital fossæ; secondly, the "lacrymal" fossa is produced forward and downward toward the buccinator fossa, while the maxillo-labialis superior muscle itself runs obliquely forward and upward, so that it crosses the anterior prolongation of the lacrymal fossa. This is well indicated in the type of *Archæohippus ultimus* (Pl. XVIII).

THE "LACRYMAL" FOSSA NOT FOR THE NASO-LABIALIS (LEVATOR LABII SUPERIORIS ALÆQUE NASI) MUSCLE

At one time I tried the hypothesis that the preorbital groove, or lacrymal fossa, of fossil Equidæ might have served as the place of origin of the "levator naso-labialis" muscle. This hypothesis is rendered improbable, however, by the following considerations: in all mammals figured by von Boas and Paulli and others the naso-labialis muscle is superficial in position and never rises from a deep fossa. Arising from the surface above and in front of the eye (Figs. 6, 8, 10), it passes over the maxillo-labialis superior muscle and runs obliquely forward and downward to be inserted in the back part of the lips. As the lower, or "malar," fossa was pretty surely occupied by the maxillo-labialis superior, we found it impossible to put the naso-labialis anywhere along the whole extent of the upper, or "lacrymal," fossa and bring it over the maxillo-labialis superior. It seems, on the contrary, highly probable that in fossil



Figs. 5-10. Facial muscles of ungulates.

5. *Sus scrofa*. Adapted from von Boas and Paulli.
6. *Tapirus terrestris*. Adapted from von Boas and Paulli.
7. *Tapirus terrestris*. Deep muscles. Adapted from von Boas and Paulli.
8. *Rhinoceros sumatrensis*. Adapted from Beddard and Treves.
9. *Equus caballus*. Adapted from von Boas and Paulli.
10. *Equus caballus*. Adapted from Ellenberger and Baum.

Showing the nasal diverticulum and the muscles of the snout.

Equidæ (Pl. XVIII) the naso-labialis arose in precisely the same place as in recent Equidæ, i. e., on the very surface of the bone immediately above and in front of the eye and immediately in front of the preorbicularis dorsalis muscles. Even in the elephant and in the tapir, which have a fully developed proboscis, the naso-labialis does not run from a deep fossa but from the surface of the bone (von Boas and Paulli, plates). In *Hypohippus osborni* (Pl. XVIII), for example, it is plainly impossible to put the naso-labialis in the very deep preorbital groove and have it at the same time pass above the maxillo-labialis superior, which runs from the maxillary bone, behind the infraorbital canal, obliquely forward and upward to the tip of the nasals.

THE "LACRYMAL" FOSSA NOT FOR A DORSAL EXTENSION OF THE BUCCINATOR MUSCLE

Von Boas and Paulli, in their beautiful figures of the variations of the buccinator muscles in many mammals, show that among the ungulates there is a transverse part of the buccinator which wraps around a longitudinal bundle that extends backward along the side of the cheek teeth. As may be seen by comparison with the skeletal parts, this transverse portion of the buccinator comes opposite the diastemata in the upper and lower jaws. In the lower jaw the longitudinal ridge of the mandible in the region of the diastema lies between the tongue on one side and the transverse portion of the buccinator on the other. Similarly, in the upper jaw the ridge or crest along the diastema separates the tongue on the one side from a fossa for the transverse part of the buccinator on the other.

Since the lacrymal fossa in many fossil Equidæ is continued downward and forward toward the buccinator fossa, I at one time thought that the former might serve for some strange backward and upward development of the buccinator, analogous in some ways to the cheek pouches of rodents.

In the kangaroo also, as figured by von Boas and Paulli, the buccinator extends well up on the side of the face beneath the maxillo-labialis superior and the naso-labialis muscles, and the lower part is received into a deep fossa (Fig. 1). In *Archæohippus* (Pl. XVIII) and other fossil Equidæ, however, the buccinator fossa is clearly separated by a ridge from the anterior (or subnasal) extension of the "lacrymal" fossa.

Finally, in dissecting a Grévy's zebra (Fig. 11) from the New York Zoological Park, we found that the buccinator muscle and its fossa were well defined above and had nothing to do with the anterior extension of the lacrymal fossa.

RELATIONS OF THE PREORBITAL FOSSÆ TO UNDERLYING SINUSES,
TO THE DENTAL ALVEOLI AND TO STRENGTHENING RIDGES
AND EMINENCES

Cross-sections of the skull of recent Equidæ in front of the orbits made by Mr. S. H. Chubb show that the outer wall of the face is very thin and that beneath it are greatly expanded sinuses in the lacrymal and

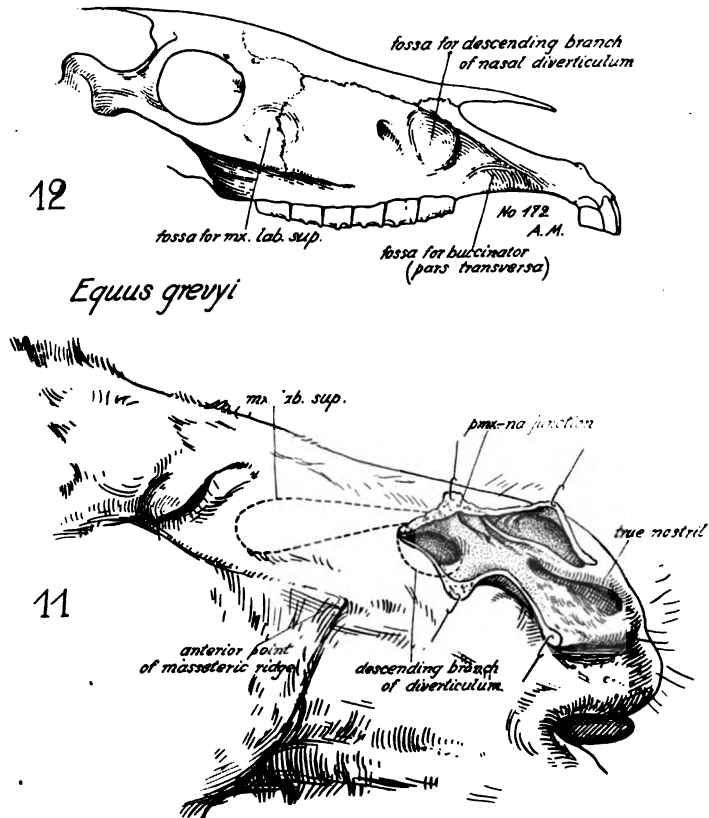


FIG. 11. *Equus grevyi*. Dissection of nasal diverticulum.
FIG. 12. *Equus grevyi*. Skull of the same individual, showing the "malar," "sul. nasal," and "buccinator" fossæ.

maxillary bones. A sinking in of the outer wall forms the "malar" and "lacrymal" fossæ at the expense of the underlying sinuses but does not interfere in the least with the nasal passage, which in all Equidæ is a high and rather compressed chamber. It is very probable that the

presence of these fossæ is partly conditioned in fossil Equidæ by the thinness of the external walls bounding the underlying sinuses.

It is a widespread principle in the construction of the skull among vertebrates that bones often tend to be strengthened along certain lines of special stress and to thin out between these lines. This principle is beautifully illustrated in the formation of the temporal fenestræ of reptiles. It is also illustrated in the lacrymal region of *Cervulus*,¹ where the pedicles of the horns are strengthened by prominent ridges on the lacrymal bone. In many Equidæ the thin walls between the nasofrontal ridge above and the malar-masseter ridge below have, in fact, collapsed beneath the maxillo-labialis superior muscle and the nasal diverticula, as described below.

The dorsad extension of the alveolar portion of the maxilla has also perhaps conditioned the collapse of the outer wall of bone immediately above it.

Finally, in the modern *Equus* the vertical deepening of the skull has apparently had a tendency to flatten out these fossæ so that even the "malar" fossa is but feebly preserved.

THE NASAL DIVERTICULA OF UNGULATES AND THEIR RELATIONS WITH THE LACRYMAL FOSSA

Murie (1872) has shown that in the Indian tapir the deep fossæ alongside of the nasal bones and above and in front of the orbits are filled with cartilaginous diverticula of the nose (Figs. 7, 14, 15, 16), while von Boas and Paulli (plates) show that the same is true in *Tapirus terrestris*. At first I thought that in the tapirs these deep fossæ were for the muscles that move the trunk, but von Boas and Paulli show that these muscles, especially the maxillo-labialis superior, are lateral to the deep fossæ in question, and located on or in front of the bony rim above the orbits (Figs. 6, 7). So, too, in the elephant these powerful muscles are more on the surface and not located in deep fossæ. In tapirs the fossæ in question show an extraordinary resemblance to the deep "lacrymal" fossæ in front of the eye in *Onohippidium* (Fig. 17) and other extinct Equidæ.

In recent Equidæ (Figs. 10, 11, 13) the true nasal passage is complicated by the addition of lateral diverticula (*div. nas.*), giving rise to the so-called false nostril, which is a blind passage usually not very extensive in domestic horses. Mr. Chubb has found it to be better developed, however, in a Burchell's zebra, and in a domestic ass (Fig. 13),

¹See Fig. 154 of the preceding article.

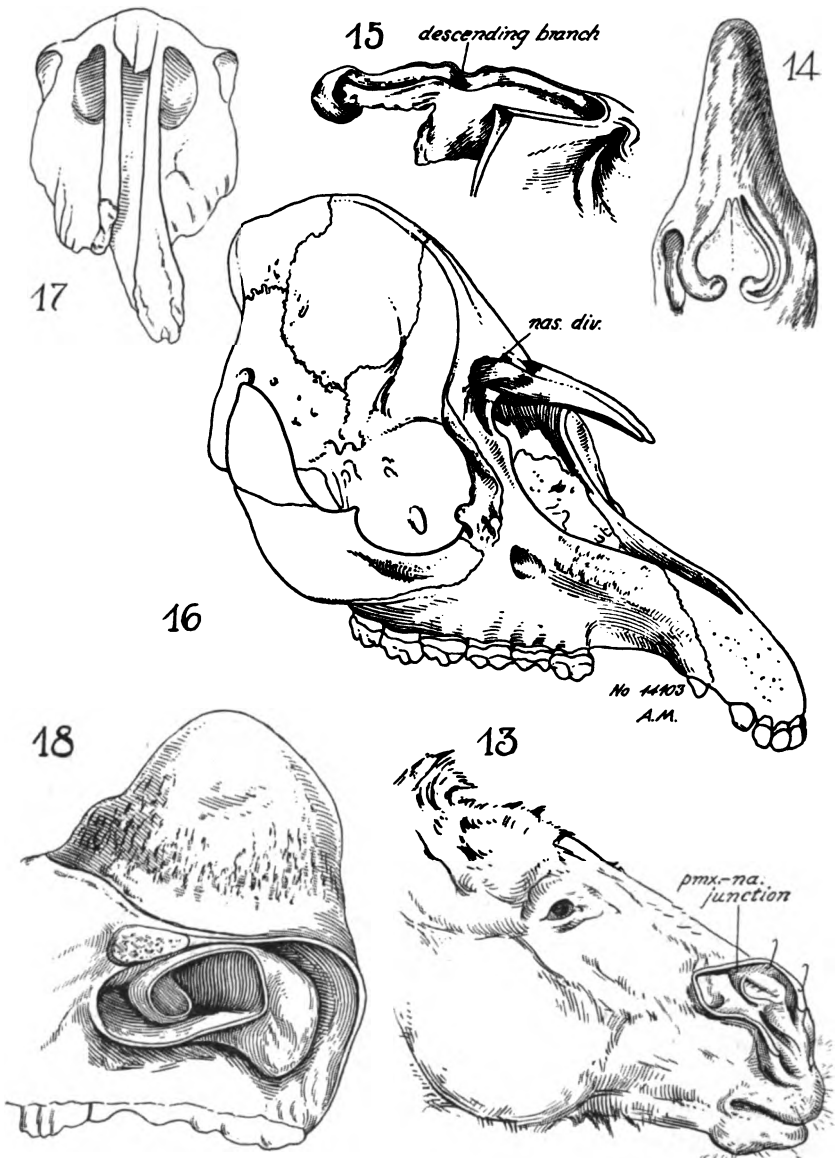


Fig. 13. *Equus asinus*. Dissection of nasal diverticulum in a domestic ass.

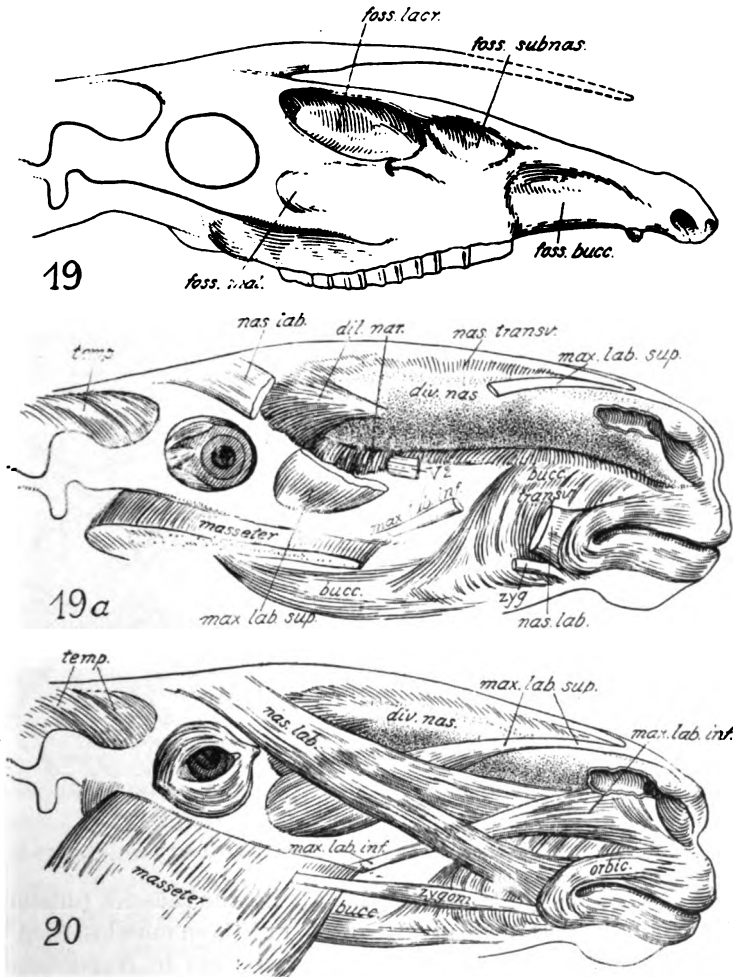
Fig. 14. *Tapirus (Rhinoceros) indicus*. Nasal diverticula and snout, dorsal view. After Murie.

Fig. 15. *Tapirus (Rhinoceros) indicus*. Left nasal diverticulum and septum seen obliquely from the right. After Murie.

Fig. 16. *Tapirus terrestris*. Oblique front view of skull showing preorbital fossae for nasal diverticulum.

Fig. 17. *Onohippidium mufizi*. Front view of type skull showing deep preorbital fossae, presumably for nasal diverticula. Adapted from Sefve.

Fig. 18. *Rhinoceros sumatrensis*. Cartilages of nasal diverticulum, partly cut away to show interior of sac. After Beddard and Treves.



Figs. 19, 19a, 20. *Onchippidium muhizi*. Fore part of skull and semi-diagrammatic restorations of facial muscles.

19. Type skull, adapted from Lydekker, showing slight "malar" fossa, very large and deep "lacrymal" and "subnasal" fossae, and a well-marked "buccinator" fossa.

19a. Attempted restoration of deep structures, showing supposed position of enlarged nasal diverticulum and surrounding muscles.

20. Attempted restoration of superficial muscles.

and we have lately had the opportunity of exploring this region in a Grévy's zebra, with the results shown in Figs. 11 and 12. The nasal diverticulum shows an extensive development lying above and well behind the inner opening of the true nostrils and below the tendon of the maxillo-labialis superior muscle. The upper and back part of the diverticulum gave off a descending branch which was lodged in a conspicuous depression on the side of the maxilla in front of the infraorbital foramen and above and behind the buccinator fossa. This fossa in recent Equidæ, then, is evidently homologous with the anterior extension of the "lacrymal" fossa in extinct Equidæ (Pl. XVIII).

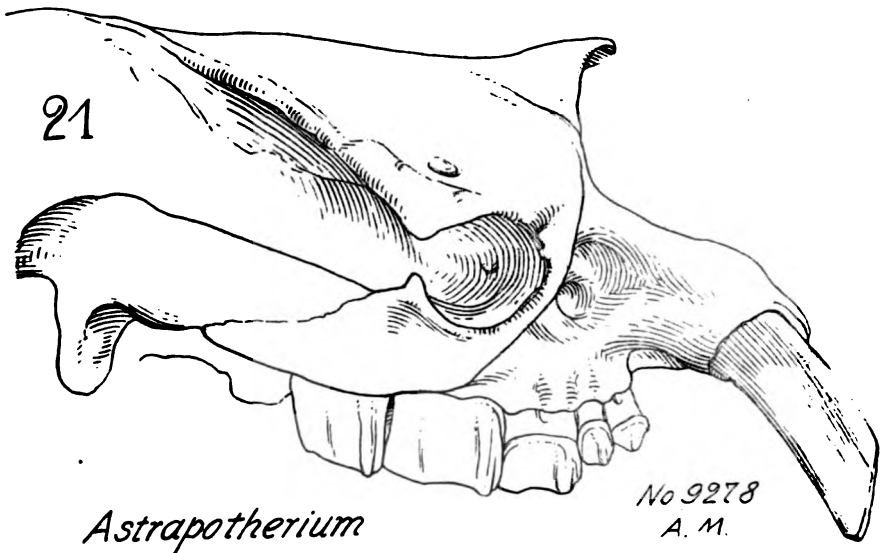


Fig. 21. *Astrapotherium* sp. Skull, showing deep preorbital fossa. $\frac{1}{4}$.

At first we sought to fill this fossa with the muscles (dilator nasi, etc.) surrounding the nasal diverticulum, but these muscles, even in the tapir and elephant, never occupy deep fossæ, and in *Hypohippus* (Pl. XVIII) the fossæ in question would be deep enough to lodge as heavy a muscle as the gastrocnemius. The presence of such a large muscle for dilating the nose would be quite inconsistent with the generally horse-like character of the front part of the skull of the extinct Equidæ.

In *Onohippidium*, also, the anterior, or "subnasal," extension of the "lacrymal" fossa (Pl. XVIII) is precisely homologous with the similarly placed fossa in the Grévy zebra, which is known to lodge a branch of the

nasal diverticulum. Accordingly, in our semi-diagrammatic restorations of fossil Equidæ (Pl. XVIII) we have filled the lacrymal fossa and its anterior, or subnasal, prolongation with an enlarged nasal diverticulum, above and around which we have placed the normal muscles of the nose and lips.

In *Astrapotherium* (Fig. 21), which, from the conformation of the nasals, was very probably supplied with a proboscis, the "lacrymal"

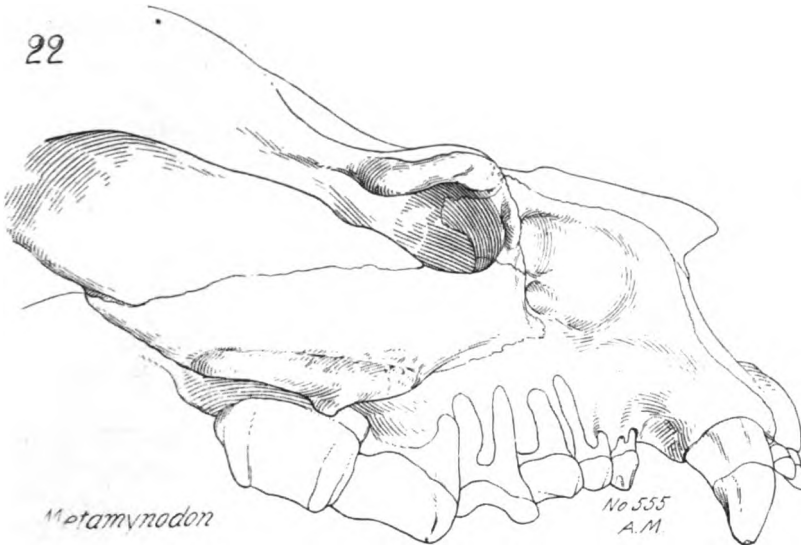


Fig. 22. *Metamynodon planifrons*. Skull, showing large preorbital fossa. $\times \frac{3}{4}$.

fossa is placed much as it is in the tapirs, and the same is true in *Metamynodon* (Figs. 22, 23), so that in these animals also these fossæ were probably occupied by nasal diverticula. There is plenty of room for the muscles of the trunk on the bony rim around the orbits lateral to these fossæ. In *Amyrnodon* (Fig. 24), which is ancestral to *Metamynodon*, the same fossa is extended on the side of the maxilla in front of the orbit and this gives the key to the function of a similar fossa in many of the Eocene titanotheres.¹

In the skulls of the recent *Rhinoceros indicus* (Fig. 25) and *Ceratotherium simum* (Fig. 26) there are shallow fossæ above the infraorbital canal, which may lodge part of the nasal diverticulum (Fig. 18).

¹Our attempted restorations of the anatomy of the face of these animals will be published in Professor Osborn's U. S. Geol. Surv. Monograph on the Titanotheres.

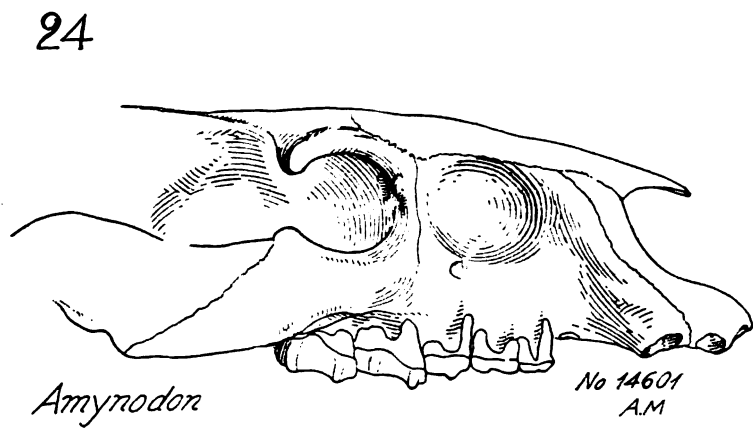
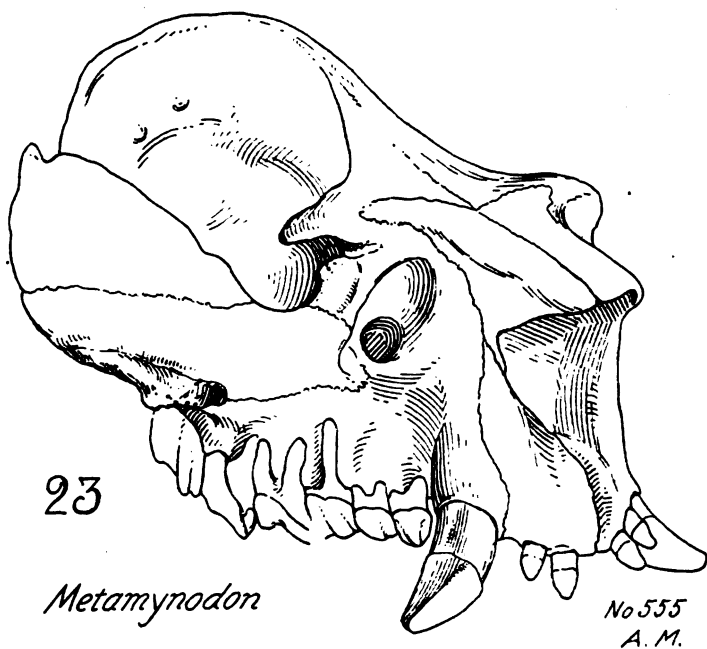


Fig. 23. *Metamynodon planifrons*. Oblique front view of skull showing preorbital fossa. (Compare *Onchippidium, Tapirus*.) $\times 29$.

Fig. 24. *Amynodon intermedius*. Skull, showing large preorbital fossa. $\times 14$.

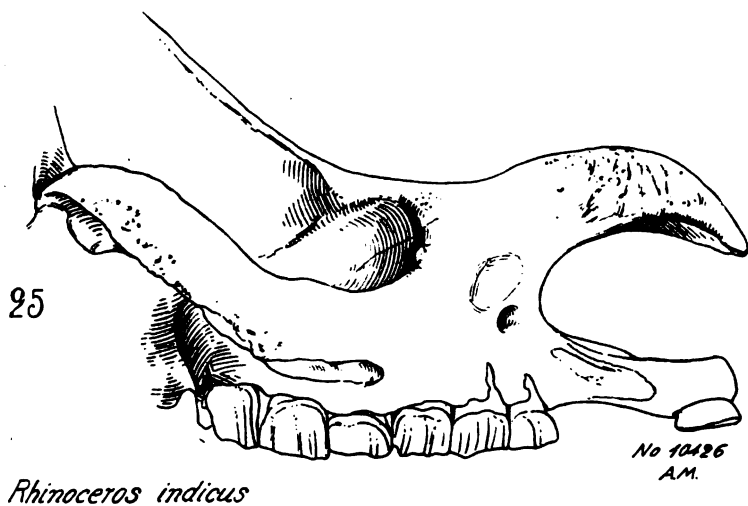
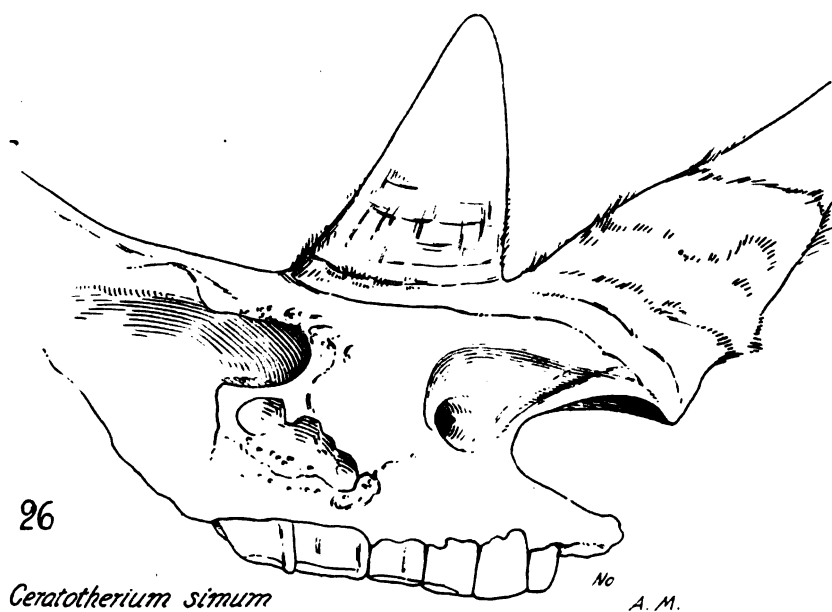


Fig. 25. *Rhinoceros indicus*. Skull, showing shallow preorbital fossa. $\times$ circa $\frac{1}{4}$.
 Fig. 26. *Ceratotherium simum*. Skull, showing shallow preorbital fossa. $\times$ circa $\frac{1}{4}$.

In all such cases it seems highly probable that the fossæ in question were partly occupied by nasal diverticula, although the bony rims above them may well have been strengthening ridges and eminences and not directly caused by the presence of the diverticula.

In *Palæotherium* the general conformation of the front part of the skull is more or less tapiroid in character but neither in this genus nor in *Paloplotherium* were the preorbital fossæ pronounced

SUMMARY AND CONCLUSIONS

Although the preorbital fossæ of *Rhynchocyon* and the Suidæ are filled by the muscles of the snout, it is not deemed safe to infer from this alone that the same was true of the preorbital fossæ of the Equidæ, for reasons advanced on pages 266,268 above.

More direct evidence, afforded by recent Equidæ, indicates that the lower or "malar" fossa was probably filled by the maxillo-labialis superior muscle.

With regard to the upper or "lacrymal" fossa, it probably did not lodge a "larmier" or facial gland for the reason that it differs markedly in appearance from the true "larmier" fossæ of ruminants. The fossa in question probably did not lodge the maxillo-labialis superior muscle chiefly for the reason that that muscle has been pretty surely allocated to the lower fossa. It did not lodge the "naso-labialis" for the reason that that muscle in recent mammals is essentially superficial in position and could not be beneath, or deep to, the maxillo-labialis superior, which runs from the "malar" fossa forward, above the infraorbital canal, and upward toward the tip of the nasal bone. The "lacrymal" fossa probably did not serve for the lodgement of a dorsal extension of the buccinator, not only because there is no direct evidence in favor of such an hypothesis, but chiefly because in many Equidæ the buccinator fossa is sharply delimited from the anterior prolongation of the "lacrymal" fossa and especially because there is more direct evidence for the conclusion stated below. Finally, the "lacrymal" fossa probably did lodge a greatly expanded nasal diverticulum, because the remnants of this structure are actually found at the anterior or subnasal extension of the "lacrymal" fossa in existing Equidæ and because the posterior extension of the "lacrymal" fossa is often extremely similar, except in size, to its anterior extension (cf. *Onohippidium*, Pl. XVIII).

The existence of both the "lacrymal" and "malar" fossæ is probably conditioned by the thinness of the outer tabula of the malar and maxillary and by the subsidence of these areas into the underlying sinus,

which subsidence is further emphasized by the upraising of strengthening ridges and eminences around the depressed areas.

In other extinct ungulates the preorbital fossæ, when present, were probably occupied by nasal diverticula, as they are in existing tapirs.

REFERENCES TO LITERATURE

- BEDDARD, F. E. AND TREVES, F. 1889. On the Anatomy of *Rhinoceros sumatrensis*. Proc. Zool. Soc. London, January 15, pp. 1-25. [Anatomy of the face.]
- BOAS, J. E. VON AND PAULLI, S. 1908. The Elephant's Head. Studies in the Comparative Anatomy of the Organs of the Head of the Indian Elephant and other Mammals. Part 1, Folio, pp. 1-79, Pls. i-xvi. Jena.
- CHAUVEAU, A., ARLOING, S. AND LESBRE, F. X. 1903. Traité d'Anatomie Comparée des Animaux domestiques. (5) I, pp. 1-684.
- ELLENBERGER, W. AND BAUM, H. 1894. Topographische Anatomie des Pferdes. II, Kopf und Hals. Berlin. Pp. v+360. [Anatomy of the face.]
- GAUDRY, A. 1862. Animaux Fossiles et Géologie de l'Attique, Paris, pp. 1-474. ["Larmier" of *Hipparion gracile*, p. 221.]
- GIDLEY, J. W. 1906. See Matthew and Gidley below.
- LYDEKKER, R. 1884. Additional Siwalik Perissodactyla and Proboscidea. Mem. Geol. Surv. India. Palæontologia Indica, (10) III, part 1, pp. iv+34, Pls. i-iv. ["Larmier" of hippoids.]
1893. A Study of Extinct Ungulates of Argentina. De Museo de la Plata. Pal. Arg., II, pp. 1-91, Pls. i-xxxii. [Skull of *Onohippidium*, Pl. xxix.]
- MATTHEW, W. D. AND GIDLEY, J. W. 1906. New or little known Mammals from the Miocene of South Dakota. American Museum Expedition of 1903. Part IV, Equidæ. J. W. Gidley, Bull. Amer. Mus. Nat. Hist., XXII, pp. 135-153. [Upper and lower preorbital fossæ named, p. 139.]
- MURIE, J. 1872. On the Malayan Tapir *Rhinocærus sumatranus* (Gray). Journ. Anat. and Physiol., VI, pp. 131-169, Pls. viii-x. [Nasal diverticulum described and figured.]
- OSBORN, H. F. 1918. Equidæ of the Oligocene, Miocene, and Pliocene of North America, Iconographic Type Revision. Mem. Amer. Mus. Nat. Hist., N. S., II, part I, pp. 1-330, Pls. i-liv.
- SEFVE, I. 1912. Die Fossilen Pferde Südamerikas. Kungl. Svenska Vetenskaps Akad. Handl., XLVIII, No. 6, pp. 1-185, Pls. i-iii. [*Hippidium*, *Onohippidium*.]
- STEHLIN, H. G. 1889. Geschichte des Suiden-Gebisses. Abh. schweiz. palæont. Gesellsch. XXVII, part 1, pp. 1-525, Pl. x. [Preorbital fossæ lodge muscles of snout.]
- STUDER, Th. 1911. Eine neue Equidenform aus dem Obermiocæn von Samos. Sonderabdr. Verhandl. d. Deutsch. Zool. Gesellsch., pp. 192-200.
- WINDLE, B. G. AND PARSONS, F. G. 1897. On the Muscles of the Ungulata. Part I. Proc. Zool. Soc. Lond., pp. 656-704. [Facial muscles of ruminants.]

PLATE XVIII

Skulls of various recent and extinct Equidæ, with semi-diagrammatic reconstructions, showing, in the extinct forms, the supposed backward extension of the nasal diverticulum into the "lacrymal" fossa and the positions of the maxillo-labialis superior and other muscles.

Onohippidium munizi. Type skull, adapted from Lydekker, showing deep "lacrymal," "subnasal" and shallow "malar" fossæ.

Equus caballus. Skull, showing faint remnants of both preorbital fossæ.

Equus caballus. Semi-diagrammatic representation of the facial muscles and nasal diverticulum. Based on Ellenberger and Baum's figures and our own dissections.

Pliohippus fossulatus. Type skull, showing pronounced "lacrymal" and small but deep "malar" fossæ. After Osborn.

Pliohippus lullianus. Type skull, showing deep "lacrymal" and "malar" fossæ, partly confluent. From Osborn, somewhat modified.

Pliohippus lullianus. Restoration. The deep "lacrymal" fossa is covered by the enlarged nasal diverticulum.

Protohippus niobrarensis. Fore part of skull showing deep "lacrymal" and very shallow "malar" fossa. The buccinator fossa is deep and well defined.

Merychippus sejunctus, with restoration of muscles, etc. The "lacrymal" is confluent with the "malar" fossa.

Hypohippus osborni. Modified from Osborn. The "lacrymal" fossa is extremely deep and leads forward and downward into the subnasal fossa. There is no "malar" fossa.

Parahippus nebrascensis primus. Modified from Osborn. The shallow "lacrymal" is confluent below with the "malar" fossa. The subnasal fossa is comparatively deep.

Parahippus nebrascensis primus. Diagrammatic reconstruction.

Kalobatippus præstans. Modified from Osborn. Very shallow "malar," tending to be confluent with the "lacrymal" fossa. Subnasal fossa large but shallow.

Archæohippus ultimus. Incomplete type skull, after Osborn, showing large "malar," "lacrymal" and "subnasal" fossæ.

Miohippus meteulophus. Skull, modified from Osborn, showing deep "lacrymal" and no "malar" fossa (Compare *Hypohippus*).

Miohippus meteulophus. Diagrammatic reconstruction.

**Article IV.—HYNNIS AND ALECTIS IN THE AMERICAN
MUSEUM OF NATURAL HISTORY**

BY JOHN TREADWELL NICHOLS

PLATE XIX

In November 1913 the Museum received a mounted Silverfish (*Hynnys cubensis*), thirty-one inches long not counting the caudal fin, which had been captured in February of the same year at Palm Beach, Florida by Mr. John D. Crimmins. This we believe to be the first record of this rare and interesting fish, described from Cuba in 1860, from the shores of the United States. The exact relation of *H. cubensis* to its nearest allies is an interesting, as yet unsettled, problem. It will be worth while to review our material bearing on its solution.

HISTORICAL

In 1833 Cuvier and Valenciennes¹ recognized four genera of Silver and Threadfishes as follows: *Scyris* (*indica*, *alexandrina*); *Blepharis* (*indicus*, *sutor*, *major*); *Gallichthys* (*major*, *chevola*, *egyptiacus*); and *Hynnys* (*goreensis*); nine species in all.

In 1880 Lütken,² with laudable courage and, as it has turned out, a scholarly grasp of the fishes' relationships, reduced all these and other described species to three or four which he placed in the single genus *Gallichthys*, the basis for this reduction being that Threadfishes (*Blepharis* and *Gallichthys* forms) with growth approached the *Hynnys* through the *Scyris* form. His four species were *Gallichthys gallus* and *ciliaris* (East Indian), *Gallichthys aegyptiacus* (Mediterranean and West African), and *Gallichthys crinitus* (Mitchill, 1826, Shoreham, N. Y.), the Atlantic American species close to and doubtfully distinct from *ciliaris*. *Hynnys cubensis* he considered the full-grown form of *crinitus*.

In 1896 Jordan and Evermann³ followed Lütken's conclusions except for the genus *Hynnys* which they considered distinct and of which they mentioned four species: *Hynnys cubensis*; *Hynnys hopkinsi* (published here for the first time with Jordan and Starks as authors) known from a single specimen from the west coast of Mexico; *Hynnys goreensis*; and *Hynnys alexandrinus*, "the Egyptian species," with which they presumably intended to synonymize *Scyris alexandrina* Cuvier and Valenciennes. For the rest, they replaced Cuvier and Valenciennes' generic name,

¹Cuvier and Valenciennes, 1833, Hist. Nat. des Poissons, pp. 145-177, 195-198.

²Lütken, Chr., 1880, Spolia Atlantica, pp. 538-542, 604-605.

³Jordan and Evermann, 1896, Fishes of North and Middle America, I, pp. 931-933.

Gallichthys, with Rafinesque's earlier one, *Alectis*, and synonymized *crinitus* with *ciliaris*, with which, doubtless rightly, they considered it identical. They also called attention to the inavailability of *gallus*, first used for *Selene vomer*, for the form so designated by Lütken.

In 1905 these same authors¹ synonymized the East Indian fish ("gallus," or more properly, *indicus*²) with *ciliaris*. We find, then, five species current: *Alectus ciliaris*, *Hynnys goreensis*, *cubensis*, *hopkinsi*, and *alexandrinus*.

MUSEUM MATERIAL

Alectis ciliaris (Bloch)

From more plentiful material referable to this species, measurements of specimens of different sizes have been tabulated to show the changes with age. No differences between specimens from Japan (*ciliaris*) and the Atlantic coast of the U. S. (*crinitus*) can be found. All (our largest is 7 inches) show at least indications of characteristic dark cross-bands.

Alectis indicus (Rüppell)

The Museum collections contain a specimen of this species collected at Batavia, Java, by Owen Bryant, April 2, 1909. This is 8 inches long to base of caudal and, therefore, fairly comparable with the largest *ciliaris*. In view of its unlikeness to that fish it seems remarkable that the two should have been confused. The smaller eye and deeper pre-orbital give it a quite different appearance and the greater number of gill-rakers should form an easy criterion for younger individuals if they resemble one another as they are said to do. Lütken's differentiation of the two species³ is perfectly tenable; there is not the least doubt that he was right in separating them and that more recent authors who have confused the two are in error. Furthermore, Bloch, 1788⁴ (as *gallus* = *indicus* and *ciliaris*), and Rüppell,² 1828 (as *indica* and *faciatus* = *ciliaris*), both figured the two species in juxtaposition so as to bring out their specific characters very well.

Our Batavian specimen has the following characters: length to base of caudal 8 inches; teeth in narrow bands, small, the outer a little the largest and heaviest; depth in length, 1.7; eye, 4.5 in head, 2.1 in snout;

¹Jordan and Evermann, 1905, *Fishes of Hawaiian Ids.*, Bull. U. S. Fish Comm., XXIII (1903), part 1, pp. 200-202.

²The earliest name available for this fish appears to be *indicus*, *Scyris indica* Rüppell (1828, *Atl. Fishes*, *Fische des rothen Meeres*, p. 128, Pl. xxxiii, fig. 1. *Djetta*) being referable to it.

³Lütken, Chr., 1880, *Spotlia Atlantica*, pp. 539-532, 604-605.

⁴Bloch, 1788, *Ichth.*, VI, Pls. cxcvi and cxcvii.

Table 1
Specimens of *Alectis ciliaris* (Bloch), of varying sizes

A. M. N. H. Nos.	889	969	3225	899	4433	4433
Locality	Japan	New York	North Carolina	Japan	North Carolina	North Carolina
Length to Base of Caudal Teeth	2.0 inches Very small	2.6 inches Small, sharp, in very narrow bands	3.7 1/4 inches Small, sharp, in narrow bands	4.4 inches Small, sharp, in narrow bands	6.4 inches Small, comparatively smaller, in broader bands than smaller specimens	7.0 inches Same as in preceding
Depth in Length	1.0	1.0	1.3	1.2	1.5	1.6
Eye in Head	2.8	2.5	3.0	3.2	3.5	3.6
Snout in Head	3.5	3.0	3.0	3.3	3.4	3.3
Pectoral in Head	1.0	broken	1.0	1.0	0.9	0.9
Ventral in Head	0.5	0.6	0.7	1.4	1.6	1.8
Dorsal and Anal Lobes	Filamentous rays to far beyond caudal	Filamentous rays to beyond caudal	Filamentous rays to far beyond caudal	Filamentous rays to far beyond caudal	Filamentous rays of dorsal to beyond caudal, all but most posterior one broken from anal leaving lobe 2.5 in head	Filamentous rays to far beyond caudal
Dorsal and Anal Spines	Small and distinct	Small and distinct	Small and distinct	Barely evident	Lacking	Dorsal lacking, anal barely evident
Dorsal Soft Rays	18	18	18	18	18	18
Anal Soft Rays	16	16	16	16	15	16
Curve Lat. Line in Straight Part	1.0	1.3	1.1	1.1	0.9	0.9 1/2
Scutes	Too small for count	About 10 evident	6 very weak + 9 better developed	About 13, of which 2 or 3 first and 1 or 2 last very poorly developed	15, first 5 scarcely differentiated	14, first 6 scarcely differentiated
Gill-rakers	18	18	18	18	17	18

pectoral long and falciform, 1.6 in depth, .8 in head, to opposite 14th dorsal ray; ventrals short, extending two-thirds the distance to the origin of the anal. Several dorsal and one or two anal rays elongate as filaments which reach to opposite the caudal; slight scars only indicate the earlier position of dorsal and anal spines. Dorsal with 19, anal with 16 soft rays. Curve of lateral line 1.5 in straight part. Scutes poorly developed, 10 on the peduncle, the central ones well keeled. Gill-rakers 28. Unbanded.

Cuvier and Valenciennes' figure of *Gallichthys major*¹ is of a younger specimen of *indicus*,² with depth 1.4, ventrals still elongate, dorsal spines conspicuous, curve of lateral line 1.7 in straight part, pectoral .7 in head, eye 2.0 in snout. Stead³ has recently figured as *Caranx gallus* from New South Wales a more mature specimen of *indicus* which has depth 2.0, ventral short, 1.6 in head, curve of lateral line not quite 1.4 in straight part, pectoral .6 in head, but reaching only to 11th dorsal ray, filaments of vertical fins reduced. Eye 2.2 in snout.

***Hynn timerensis* Cuvier and Valenciennes**

The American Museum Congo Expedition brought the Museum two specimens of this form from the mouth of the Congo. The larger of these is 18 inches to base of caudal, the smaller 14.2 inches. No trace remains of dorsal or anal free spines in either specimen. The teeth are very small in narrow bands. The dorsal and anal origins are superimposed; that is, the anal origin is a little less anterior than in Cuvier and Valenciennes' figure but more anterior than in *Hynn timerensis*. Black axillar spot and opercular blotch are more or less evident.

Characters of the larger fish follow: length to base of caudal, 18 inches; depth, 1.9 in this measure; head, 3.3; eye, 4.3 in head; snout 2.1½; pectoral, .8; ventral, 2.4. Dorsal and anal without filaments, their lobes 1.8 in head. Curve of lateral line 1.3 in straight part. Dorsal with 21, anal with 18 soft rays. Scutes very small, 9 with sharp keels, 3 before these well developed, 6 before these barely appreciable. Gill-rakers 34.

Corresponding characters of the smaller fish are: length, 14.2 inches; depth, 1.8; head, 3.4; eye, 4.9; snout, 2.1; pectoral, .8½; ventral, 2.4. Dorsal and anal lobes each with an initial filament,—to tip of dorsal fila-

¹Cuvier and Valenciennes, 1833, Hist. Nat. des Poissons, IX, Pl. CCLIV.

²Lütken made a slight error in referring this figure to *crinitus*. *Blepharis major* was *crinitus*, but *Gallichthys major* was *indicus*, at least the figure.

³Stead, 1908, Edible Fishes of New South Wales, Pl. LVIII.

ment .8. Curve of lateral line 1.4 in straight part. Dorsal with 20, anal with 19 soft rays. Scutes very small, about 18, of which the 3 most anterior are scarcely differentiated and the 1 or 2 most posterior minute.

Thus the smaller of our two specimens has dorsal and anal filaments, an *Alectis* character, and in the doubtless deeper, more compressed young one would expect to find other such filaments. In fact, it is not difficult to agree with Lütken that Valenciennes' figure of *Gallichthys ægyptiacus* in the third edition of Cuvier's 'Regne Animal' is as such a young fish should be. Whether or not it be the same as *goreensis*, there can be little doubt that *ægyptiacus* is identical with *Gallus alexandrinus* Geoffroy on which *Scyris alexandrina* Cuvier and Valenciennes is based.

Carus, 1893,¹ evidently accepts Lütken's opinion that *Gallichthys ægyptiacus* Cuvier and Valenciennes, which he gives as synonym of *Caranx alexandrinus* (Geoffroy), is the young of *Hynniss goreensis*, as he states that *Caranx alexandrinus* has dorsal spines only in the young and is found on the coast of West Africa. It should be noted that his scute-count is lower than of our *goreensis*, and that Valenciennes' figure of *ægyptiacus*, above referred to, shows no scutes. Although in related species the full number of scutes may be made out in the young, scutes are smaller in this species and likely not all appreciable until the fish has reached a large size. The probabilities are great that *alexandrinus* of the Mediterranean and *goreensis* of West Africa are really identical, and, if not identical, are at least very close, both undergoing considerable age changes.

***Hynniss cubensis* Poey**

The mounted specimen, previously referred to has the following characters: length to base of caudal, 31 inches; teeth fine, about uniform in size, in rather broad bands; depth in length, 2.8; head, 3.9; eye in head, 5.2½; snout, 2.3; pectoral, .7, to about opposite 8th dorsal ray; ventral, 2.2½, extending a little less than half-way to anal; dorsal and anal lobes respectively 2.0 and 2.5, their rays evidently broken at the end, whence we deduce that the fish, in youth, had filaments characteristic of this group. No dorsal or anal spines. Dorsal with 19, anal with 16 soft rays. Curve of lateral line, 1.0 in straight part. Scutes, 10 on peduncle, the 3 anterior very weak. Anal origin somewhat posterior to dorsal. As this is a mounted specimen the depth of body may not be reliable, and the gill-rakers can not be counted.

¹Carus, J. V., 1893. *Prodromus Faunæ Mediterraneæ*, II, p. 671.

Besides the less depth, and the lack of filamentous dorsal and anal rays, this specimen differs from *ciliaris* of 7 inches and less in the smaller eye, deeper preorbital giving a greater snout measurement, fewer scutes, longer pectoral, and resembles them in the long curve of the lateral line. In these respects it compares with the 8-inch Batavian *indicus*, from which, however, it differs in the same long curve of the lateral line. But comparing this lateral line curve with figures of *indicus* of different sizes, it seems probable that same lengthens with increased size and reduced depth of the fish, that the measurement in our mounted specimen is what would be expected for a large *indicus* and is less than one should find in a large *ciliaris*. Of the two, it should be placed with the former, which is known to reach a large size, and indeed it is easier to understand that an occasional stray of an East Indian free-swimming fish should reach the West Indies, as the Whale Shark is known to do, than that the common, cosmopolitan *ciliaris* should be known in its adult form only from an occasional West Indian record. The greatest drawback to synonymizing *cubensis* with *indicus* is that Day¹ says of "*gallus*" = *indicus*: "Teeth apparently villiform in young in jaws . . . , but in adults (23 inches long) they assume an entirely different (or *Sparoid*) character, having rounded crowns, 5 rows in premaxillaries, and 4 in lower jaw, decreasing to 2 or 1 row behind," whereas our large *cubensis* has approximately villiform teeth. Possibly Day is in error here, for the general tendency is for carangid teeth to become more villiform with age, rather than less so.

DISCUSSION

These fishes are all closely related. By British authors they are included with a host of more generalized forms in the genus *Caranx*. The remarkably specialized young, and the very extent of their age-changes, however, justify their separation, which is also a matter of convenience. *Goreensis*, the type of *Hynnys*, and probably identical with *alexandrinus*, is also less closely related to *Hynnys cubensis* and *H. hopkinsi* (see beyond) than these are to *Alectis indicus* and *A. ciliaris*. There is no excuse either in the fishes' relationship or in convenience for recognizing the genus *Hynnys*, and all recognized species, whether the young or the old form, should stand as *Alectis*.

So far, little mention has been made of *hopkinsi*, known from a single specimen 26 inches long taken on the west coast of Mexico. This specimen has not been examined but there is an excellent figure of it which

¹Day, 1889, Fauna of British India, Fishes, p. 166.

shows the eye 1.8 in snout, curve of lateral line .7 in straight part (1.0 in description).¹ From the appearance of the rays in dorsal and anal lobes we judge that when younger it had filamentous rays. Dorsal and anal rays are given as 18 and 15, scutes 12, gill-rakers 12. This, more than any other specimen we know of, suggests an overgrown *ciliaris*, but the gill-rakers are definitely too few and it should stand as a distinct species.

Whereas the structural changes with size in *ciliaris* parallel those in *indicus*, we know of no material tending to prove that *ciliaris* reaches a very large size or, like *indicus*, becomes a fish of very different character from what it is when small. It is not improbable that it retains the characters which are more or less larval elsewhere in the genus. It is the commonest and most widely distributed species, found in the warmer parts of the Atlantic, Pacific and Indian oceans, and drifted northward in the Gulf Stream and corresponding Japan Current of the western Pacific.

REVIEW OF THE GENUS *Alectis*

Alectis comprises marine fishes, of the subfamily Caranginae, with deep and compressed form, especially in the young (thus differing from *Caranx*, *Carangoides*, etc.), teeth in bands (like *Carangoides*), scales obsolete or absent on rest of the body as well as on chest (thus differing from *Citula*), one or more of the soft dorsal and anal rays prolonged in filaments, at least in the young (thus differing from *Vomer*), scutes few and small but always present on the peduncle (thus differing from *Selene*). Individuals undergo marked changes with growth, becoming less deep and compressed with age, the ventrals at first long, shortened by abrasion, the dorsal and anal filaments, as well as the dorsal spines, also entirely lost in those which reach a large size.

Alectis alexandrinus (Geoffroy)

Gallus alexandrinus GEOFFROY, 1809, Desc. Egypte, etc., I, part 1, Pl. xxii, fig. 2. Alexandria.

Hynniss goreensis CUVIER AND VALENCIENNES, 1833, IX, p. 195, Pl. cclvii. West Africa.

Gallichthys ægyptiacus LÜTKEN, 1880, Spolia Atlantica, pp. 538-542.

Caranx alexandrinus CARUS, 1893, Faunæ Mediterraneæ, II, p. 671.

Mediterranean and West Africa.

¹Jordan and Evermann, 1900, Fishes of North and Middle America, IV, pl. cxliii.

Alectis indicus (Rüppell)*Scyris indica* RÜPPELL, 1828, Atl., Fische, Pl. xxxiii, fig. 1. Djetta.*Caranx gallus* GÜNTHER, 1860, Cat., II, p. 455, and recent British authors.*Hynnys cubensis* POEY, 1860, Memorias, II, p. 235; Havana. JORDAN AND EVERMANN, 1896, Fishes of North and Middle America.

Indian Ocean and adjacent seas, large individuals straying to Cuba and Florida.

Alectis hopkinsi (Jordan and Starks)*Hynnys hopkinsi* JORDAN AND STARKS, 1896, in Jordan and Evermann, Fishes of North and Middle America, I, p. 933; 1900, idem, IV, Pl. cxliii. Mazatlan, west coast of Mexico.

Only the type known.

Alectis ciliaris (Bloch)*Zeus ciliaris* BLOCH, 1788, Ichth., VI, p. 27, Pl. cxci. East Indies.

Cosmopolitan in warm seas, north in the Gulf Stream and Japan Current.

KEY

Preorbital deep, eye about twice or more in snout (or one and two-thirds in the very young), gill-rakers 25 to 35.

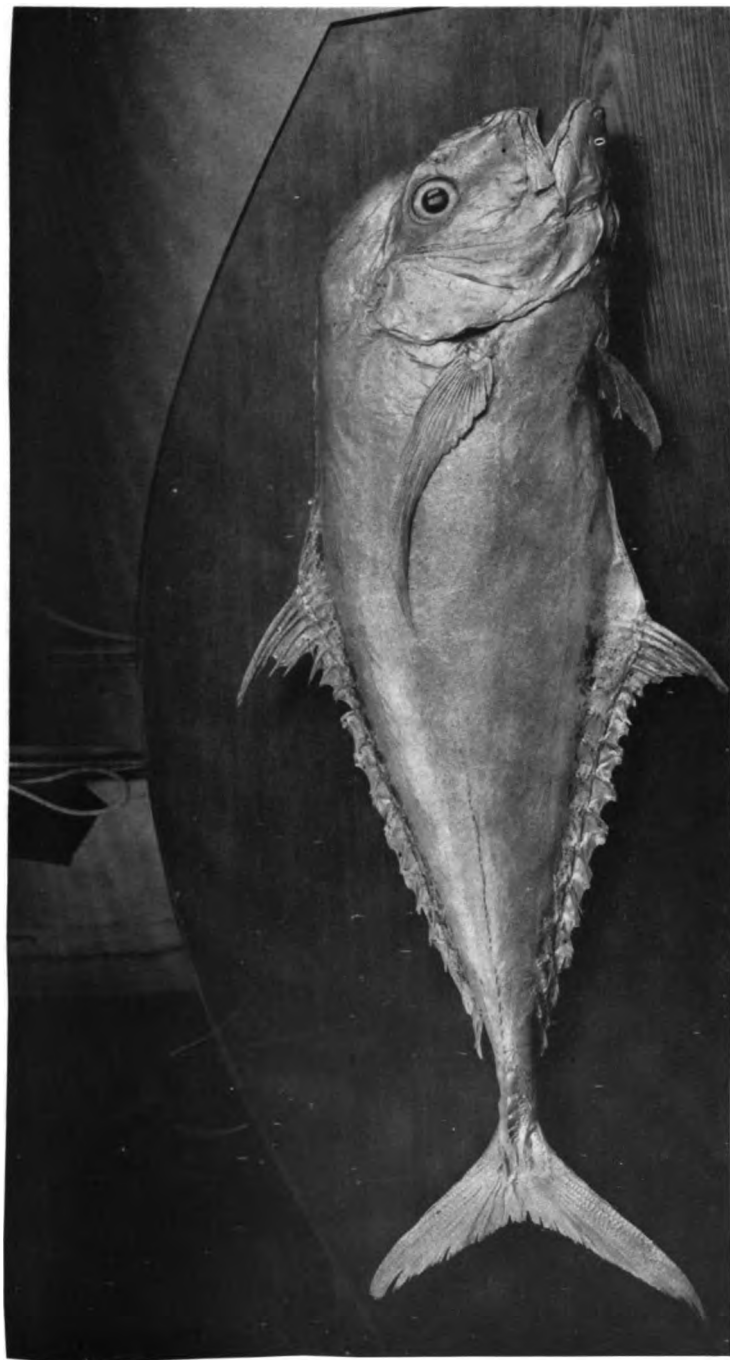
Dorsal with 21 or 22, anal with 19 soft rays. *alexandrinus*.¹Dorsal with 19, anal with 16 soft rays. *indicus*.²Preorbital less deep, eye a little less than twice in snout, gill-rakers 12. *hopkinsi*.

Preorbital narrow, eye about equal to snout, gill-rakers 17 to 18.

ciliaris.

DOUBTFUL SPECIES

¹Scutes 15 to 18, a single dorsal ray notably produced in the young. *porensis*.Scutes 14 or less, 3 or 4 dorsal rays almost equally produced in the young. *alexandrinus*.²Teeth in large fish in 4 or 5 or less rows, sparoid in character with rounded crowns. *indicus*.Teeth in large fish small, in rather broad bands. Young not known. *cubensis*.



Hymnia cubensis, 31 in. long to base of caudal. From a mounted specimen from

Article V.—NEW SPECIES AND SYNONYMY OF AMERICAN CYNIPIDÆ¹

BY ALFRED C. KINSEY

PLATES XX TO XXVII

Our present knowledge of the Cynipidæ (Hymenoptera), of the number of species, of species limits, and of species and group relationships, is decidedly incomplete. Students of the gall-wasps have been few, and from large areas of the world practically no collections of this family have been made, e. g., in the Western Hemisphere we have seen very little material from the southern and western parts of the United States, from Mexico, or from Central or South America. In consequence, we are hindered considerably in obtaining an understanding of the peculiar biological phenomena characteristic of these insects. The origin and development of gall production, of agamic reproduction, and of heterogeny especially, may be adequately comprehended only through a careful study not only of the species already described but also of many of these species yet to be described. I count it good fortune to be able to offer descriptions of sixteen new species, several of which are important items in the exposition of the very phenomena above mentioned. These species are distributed among most of the genera of the family, in a number of instances representing groups which have been hitherto the least well known, e. g., *Aulacidea*, *Diastrophus*, and *Disholcaspis*. I have also included some new and corrected synonymy.

Certain genera of the Cynipidæ are founded upon definite morphological characters which are clearly paralleled by biological considerations. But many of the species of oak gall producing Cynipidæ have long been held in groups which are based on the most meager of indefinite morphological characters, and the "genera" thus made are not confirmed by a more careful examination of the morphology and a study of the biology of the species concerned. And, moreover, until both of the alternate generations of dimorphic species can be included by a generic definition, the group remains an artificial creation. In another paper, on the phylogeny of the Cynipidæ, I am discussing this question in more detail and offering data which may be used to draw lines for natural genera. I hope to be able in the near future to revise the genera for the family.

¹Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 163.

Until that time, it is surely wise not to maintain, in the description of new species, the several "genera" known as *Cynips*, *Dryophanta*, *Callirhytis*, *Andricus*, *Biørhiza*, *Philonix*, et al., species of which groups might all be described under the designation of "*Andricus*." Under that name are now included so many species of very different form and biology that the name is very patently meaningless. In using it, I do not in the least intend to imply anything definite concerning the generic relationship of the species.

This part of my work with Cynipidæ has been done under the supervision of Dr. Wm. M. Wheeler, Dean of the Bussey Institution and Professor of Entomology of Harvard University, and of Professor C. T. Brues of the Entomology Department of the Bussey Institution. To both of these men I am deeply indebted for their continued direction and encouragement.

For the opportunity of studying the material described in this paper I am indebted to the kindness of Dr. Frank Lutz of The American Museum of Natural History, Charles W. Johnson, Curator at the Boston Society of Natural History, and Nathan Banks, of the Museum of Comparative Zoology of Harvard University. The majority of the new species here described were found in the collections of the latter institution. All of the authorities mentioned have been most liberal in offering free access to the important collections under their direction, and as liberal in their interest in and encouragement of my studies.

To Professor Brues I am further indebted for the photographs which illustrate this paper, adding considerably to the value of the work and to the availability of the descriptions.

***Rhodites vernus* Osten Sacken**

Cynips (*Rhodites*?) *tuberculosa* OSTEN SACKEN, 1861, Ent. Zeit. Stettin, XXII, p. 415.
[Description too brief.]

Rhodites verna OSTEN SACKEN, 1863, Proc. Ent. Soc. Phila., II, pp. 41, 45, 47.

Rhodites nodulosus BEUTENMÜLLER, 1909, Ent. News, XX, p. 247; 1914, Bull. Brooklyn (N. Y.) Ent. Soc., IX, p. 88, Pl. v, figs. 1-5.

Cotype galls and females of both *vernus* and *nodulosus* are in the Museum of Comparative Zoology in Cambridge. The only differences I can see in direct comparison of the two lots of galls is that the type material of *nodulosus* is smaller than the type material of *vernus*. The females seem identical except for darker markings on the hind margins of the abdominal plates—a character which is as liable to variation as is the size of the galls. *R. vernus* is quite a unique species in *Rhodites*, and all the unique characters are to be seen in the *nodulosus* types. The

"large shining area" of the pleuræ described for *nodulosus* is rather dull and not entirely smooth in the types I have seen.

***Andricus punctatus* (Bassett)**

Pla'e XX, Figures 1 and 2

Cynips q. punctata BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 324.

Cynips q. podagræ WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 492.

Andricus davis [gall] BEUTENMÜLLER, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 463.

Holcaspis globulus [error] THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 60, No. 127, editor's note.

I have examined type material of *Andricus davis* in The American Museum of Natural History, the Museum of Comparative Zoology, and in the collection of Mr. W. T. Davis. Mr. Davis has kindly given me specimens of the gall and adults from the type locality. The adults are the inquilines named *Synergus lignicola* Osten Sacken (1865, Proc. Ent. Soc. Phila., IV, p. 374), of which *davis* must become a synonym. The original description of *davis* mostly corresponds with the types. But the male antennæ are actually 15-jointed, the female 13-jointed; and no mention is made of the arcuate first abscissa of the radius, the closed radial cell, the longitudinally striate first segment of the abdomen, or other characters which are generic for *Synergus*.

The galls from which these were bred appear to be deformed specimens of *Andricus punctatus*. Walsh (1864, Proc. Ent. Soc. Phila., II, p. 499), Gillette (1889, Psyche, V, p. 185), and Beutenmüller (1910, in Smith's Cat. Ins. N. J., p. 597) record this inquiline from this gall; other inquilines and parasites are commonly bred from it.¹

In studying the Thompson Collection in the Boston Society of Natural History, I find the material of No. 127 of Thompson's Catalogue to be this same gall, with a large part of the insects bred being *S. lignicola*. The gall *davis* was described as occurring on *Quercus ilicifolia*; the Thompson material came from both *Q. ilicifolia* and *Q. rubra*. Although normal *punctatus* is more often found on *Q. rubra*, *Q. velutina*, or *Q. coccinea*, it is also found normal on others of the black oaks including *Q. ilicifolia* (cf. Beutenmüller, 1904, Amer. Mus. Nat. Hist. Guide Leaflet 16, p. 13; and Viereck, 1916, Hymen. Conn., p. 431).

The parasitized or inquiline-inhabited galls are quite different from normal galls of the species. Compare Figs. 1 and 2 of Plate XX. In-

¹After I had written the above, Mr. Lewis H. Weld drew my attention to similar abnormal galls which were evidently developed from galls of another species of *Andricus*. It would seem that *Synergus lignicola* may affect in similar fashion more than one species of cynipid gall; or it is possible that I am wrong in believing *Andricus punctatus* to be ever involved.

fested galls are usually more or less globular, in groups, but not so completely fused into a single mass as normally. Internally these galls are only loosely woody, with several small larval chambers (without a distinct larval cell-wall) arranged somewhat radially and near the bark. Each portion of the fused mass of the normal gall is woody and will contain toward the center one to three good-sized larval cells with a distinct cell-wall. This is a typical instance of the change effected in the structure of a gall when it becomes inhabited by inquillines. A few other similar instances are well known; it is likely that many others will come to light. A careful study of these might indicate some of the factors which act to produce galls. In *A. punctatus* the "inquiline" seems to be more truly a parasite, for usually gall-wasps are not reared from galls which breed out the *Synergus*, nor is the gall-maker's larval cell found to be developed to any size. It is likely that the *Synergus* does not attack the *Andricus* larva directly, but indirectly by robbing it of the food in the gall.

***Aulacidea abdita*, new species**

Plate XXI, Figures 6 and 7

FEMALE.—Head and thorax dark piceous (not black), face distinctly rufous, a prominent median elevation on the front, abdomen darkest terminally (not dorsally and basally); areolet moderately large. **HEAD:** piceous, the face bright rufous, shading to red or yellowish red at the mouth-parts, coriaceous, with a few short hairs; the face rather irregularly striate, with a moderate median elevation on the face and a separate and prominent median elevation on the front bearing the ocelli. **Antennæ** 13-(14-)jointed, dark rust-brown, the first two joints reddish brown or bright red; covered with short hairs. **THORAX:** piceous, usually dark, but not black; mesonotum finely rugoso-punctate, covered with short hairs; parapsidal grooves distinct, continuous to the pronotum, widely separated at the scutellum; median groove distinct for a short distance from the scutellum, its further extension being indistinct to a point one-quarter of the way to the pronotum; anterior parallel lines distinct, extending half the way to the scutellum; lateral lines distinct, extending half the way to the pronotum; scutellum finely rugose with the two small foveæ divergent, widely separate, smooth; mesopleuræ shining, aciculate. **ABDOMEN:** shining, smooth, dark red, rufous to piceous terminally, brighter red or yellowish red basally, with a patch of white hairs on each side of the second segment basally. **LEGS:** quite uniformly reddish yellow, the tips of the tarsi slightly darker. **WINGS:** veins brown; areolet distinct, moderately large or large; cubitus hardly reaching the basal vein; radial cell entirely closed; first abscissa of the radius arcuate. **LENGTH:** 1.5–2.0 mm.

MALE.—Similar to the female, but differing as follows: antennæ 14-jointed, third joint curved (but only slightly so), whole antenna reddish yellow, the same color as the legs; median groove less distinct and shorter; abdomen much shorter than in the female, rufous to piceous, and quite dark on the posterior half; wing-veins lighter brown than in the female, the areolet large or very large and elongate on the cubitus toward the basal vein; length, 1.2–1.7 mm.

GALLS.—None. The insect lives in cavities (Figs. 6 and 7) in the pith of the stems of *Lactuca elongata* and most likely of other species of *Lactuca*. There is no

proliferation of the pith-tissue and scarcely any differentiation of the lining of the larval cells. These cells average 2.0 mm. by 1.2 mm. Externally, the stem shows no trace of a gall.

RANGE.—Canada: Quebec (Couper Coll.).

COTYPES.—Thirty-three females, twenty males, and ten pieces of infested stems as cotypes, in the collections of The American Museum of Natural History, the Museum of Comparative Zoology, and in the author's collection. The stems were collected about forty years ago. I cut the cotype adults from the stems and many of the specimens are imperfect or barely mature.

I cut one parasite, an eurytomid, from the same stems.

The insects superficially resemble the adults of *Aulacidea bicolor*, but the two species differ in many respects. The most conspicuous key characters of *abdita* are the rufous face (in *bicolor* only the mouth-parts are rufous or black), the very prominent median frontal elevation (practically absent in *bicolor*), the uniformly yellowish red antennæ of the male (the two basal joints are darker or piceous in *bicolor*), and the large areolet of the male (in *bicolor* the areolet is small or almost lacking). I have bred large series of true *bicolor* and have examined material from many localities and there seems to be no variation of the species toward the characters of *abdita*.

A considerable amount of data which I am bringing together elsewhere shows that the Aulacini are in very many respects the most primitive of the gall-wasps. The biology of species of the genus *Aulacidea* is hardly different from that of "normal" phytophagous Hymenoptera, lacking the remarkable phenomena such as production of complicated gall structures, agamic reproduction, and alternation of generations so characteristic of the higher Cynipidæ. The galls in this genus are all very simple. In this respect the most primitive of all the species we have known previously is *Aulacidea bicolor*: it produces no gall, but lives in the pith of stems. A very few other species of closely related genera match *bicolor* in this respect, e. g., *Phanacis centaureæ*, *Aylax rufus*, and *A. gillettei*. But we have not sufficiently realized that there might be many species of *Aulacidea* with as primitive characteristics, and I imagine that we have carelessly labelled all specimens of *Aulacidea* which have not come from distinct galls as being of the species *bicolor*. The difficulty of locating the insects in a plant which shows no external evidence of its infestation also accounts for the previous neglect to discover these primitive species. By extensive collecting of old stems of *Lactuca* in May and early June, I was able to secure quantities of infested material, breeding large series of insects from it, and I have been surprised at the variety of species obtained. I found true *A. bicolor*, *A. podagræ* very abundantly

(sometimes this species causes a noticeable gall), *A. tumida* (not known previously except from well-developed galls), and still other species which I shall study further before describing. In going over museum material of the same sort I have found the species here described to be very distinct from *bicolor*.

It is very likely that there are, still in existence today, many distinct species of Cynipidæ of primitive relationships and not yet discovered because of their hidden locations in plants. It promises to prove very profitable if we search widely for these wasps among herbaceous plants which have their dead stems persisting throughout the winter, especially pithy stems of Composites of many genera. Though *Lactuca* has proved the most heavily infested thus far, it is very likely that other plants are also thus attacked.

***Aulacidea annulata*, new species**

Plate XX, Figures 3 to 5

FEMALE.—Antennæ golden brown, the second joint almost black; abdomen bright red with two black bands dorsally at the base; areolet small; first abscissa of the radius slightly angulate; length 3.5 mm. **HEAD:** black, the mandibles rufopiceous, their tips black; coarsely aciculated, the aciculations radiating somewhat from the mouth; face with a prominent, broad median elevation; entire face covered with grayish hairs. Antennæ 13-jointed, brownish with a reddish tinge, joints three to thirteen longitudinally striate, slightly pubescent, first joint bright red or rufous, second joint and basal half of third joint piceous or black. **THORAX:** entirely black; mesonotum punctate, covered with short, grayish hairs; parapsidal grooves distinct, smooth, reaching the pronotum; median groove distinct, rather deep, extending one-third or more of the way to the pronotum; anterior parallel lines distinct but not deep, extending one-third or more of the way to the scutellum; lateral grooves distinct, about as long as the median groove; scutellum rugoso-punctate, the two foveæ large, shining, but not smooth; the pronotum, lower edge of the mesopleuræ, and metapleuræ densely hairy; the mesopleuræ shining, deeply aciculate. **ABDOMEN:** bright red, shining, two-thirds of the second segment dorsally and basally, and the dorsal and anterior half of the third segment almost or quite black; abdomen very finely and microscopically punctate, a very few hairs at the base of the second segment laterally, at the top of the seventh segment, and on the ventral edge of the hypopygium; the abdomen large, about oval, with the second segment very short, no longer than the third, these two segments together only a little more than one-half the total length of the abdomen. **LEGS:** golden to reddish brown, the coxæ bright red or slightly suffused with piceous, the hind femora darker than in the other legs, the last tarsal joints in part and all of the tarsal claws dark brown or black; legs entirely punctate, pubescent. **WINGS:** clear; all the veins dark brown; areolet usually small or lacking but variable in size; cubitus apparently not reaching the basal vein, but a colorless trace of the vein may in certain lights be seen extending the rest of the way to the basal vein; radial cell entirely closed; first abscissa of the radius quite arcuate but with a suggestion of an angle or rarely an actual projection at a point slightly above the middle. **LENGTH:** about 3.5 mm., and all of the cotypes are remarkably uniform in length.

MALE.—Similar to the female, but differing in the following respects; antennæ 14-jointed, reddish or golden brown, joints 1 and 2 dorsally dark rufous to piceous, third joint curved; abdomen rufous to piceous, darker dorsally, almost black basally on the dorsal surface; areolet averaging larger than in the female; length, 2.5–3.2 mm.

GALLS.—Terminal swellings of a stem (Figs. 3 to 5), more or less club-shaped and somewhat bent and twisted, the enlargements gradual from the stem, of greatest diameter at the summit. Very much like some galls of *Aulacidea tumida*. Averaging about 70 mm. long by 18 mm. in greatest diameter. Under the bark the plant tissue is twisted, resembling the trunk of a wind-beaten tree. Many leaf petioles or stems of flower clusters are grouped at the summit of the gall, their bases involved in the swelling. Internally the galls are filled with pith, scattered through which are many larval cells, each oval, averaging 3.5×2.5 mm. The cells are merely cavities in the pith, without a separable or even distinct tissue to form them (the cells are often lined with the cast pupal skins of the insects). On *Lactuca* or possibly *Prenanthes* (the dead stems not exactly determinable).

RANGE.—Massachusetts: Sharon.

COPYES.—One hundred and four female, sixteen male, and six gall cotypes in the collections of The American Museum of Natural History, of the Museum of Comparative Zoology, of Mr. Lewis H. Weld, and in the author's collection. The adults were all bred from galls which I collected from a single cluster of plants.

The adults emerged from June 5 to 12, 1919, the eggs undoubtedly having been deposited in the young plant in the previous June, the pupæ overwintering in the dry stems of the host plant. Almost all of the males emerged before any of the females appeared; after thirty-six hours the females began appearing and the resulting ratio was 84 per cent females to 16 per cent males. Two parasites were bred from the galls.

The adult of this species is somewhat like that of *A. tumida*, but *annulata* is readily distinguished by the key characters given at the beginning of the description.

The galls of *annulata* are not much different from some of those of *A. tumida*, although the adult is distinct. It is quite likely that there are many species in this, a primitive genus of the Cynipidæ, which are not yet known, being mistaken for other species with similar galls. These galls are simple swellings of the stems of herbaceous plants, with some proliferation of the pith-cells, but with the resulting deformations all so slight (comparatively) that the galls of different species are not distinguished as completely as are the galls of the higher cynipids.

***Diastrophus tumefactus*, new species**

Plate XXI, Figures 10 and 11

[No name, gall only] JARVIS, 1909, 39th Report Ent. Soc. Ont., p. 79.

FEMALE.—Length under 2.0 mm.; thorax mostly black, legs and antennæ uniformly golden brown; wings without areolet. **HEAD:** rufo-piceous, almost black on the vertex, reddish toward the mouth-parts; mandibles large, brownish; head finely coriaceous except for a smooth median elevation and the usual aciculated cheeks

and fan-shaped striations toward the mouth; face sparsely hairy, hairs longer toward the mouth; antennæ quite uniformly light golden brown, only very slightly darker toward the tips, 14-jointed, hairy. THORAX: black, the pronotum, scutellum, and sides piceous or black; mesonotum smooth, shining, finely rugose laterally, with a very few, scattered, short hairs; parapsidal grooves deep, continuous to the pronotum, widely separated at the scutellum, and almost parallel; median groove very faint but extending almost one-third of the way to the pronotum; anterior parallel lines barely indicated by slight depressions; scutellum rounded posteriorly, deeply rugose, and in large part striate, the striæ distinctly converging (more so than in other species of the genus) at the ridge separating the foveæ and at the sides of the foveæ, the foveæ large, deep, shining, with a few faint cross-striations; pronotum broad, rugoso-striate; mesopleuræ rufous to piceous or black, evenly aciculated. ABDOMEN: reddish piceous, darker dorsally and posteriorly, entirely smooth and shining, the second segment dorsally extending over one-half the length of the abdomen, but very small in lateral extent. LEGS: quite uniformly golden brown, covered with short hairs; claws toothed. WINGS: entirely clear, only very microscopically pubescent; veins dark gold or light brown, without any cloudings; areolet entirely absent; cubitus extending to the basal vein; radial cell rather broad, open; first abscissa of the radius slightly arcuate, not at all angulate. LENGTH: 1.7-2.2 mm.

GALLS.—Nodular swellings of the stem (Figs. 10 and 11). Polythalamous or agglomerate, i. e., many separate cells near together in a single stem. Each swelling averages about 15 mm. long by 10 mm. in diameter, but several swellings will fuse to make one gall 7 cm., more or less, in length; it is covered with the smooth bark of the stem, but has scattered, very minute, blunt spines. The larval cells within are distributed irregularly through the pith which proliferates somewhat about the chamber, but this cell is not separable, nor is it formed of a distinct layer. On the stems of *Potentilla monspeliensis* var. *norvegica* (Linnæus) Rydberg.

RANGE.—Canada: Quebec (Couper); Ontario (Jarvis).

COTYPES.—Nine female and one gall cotypes in the collection of the Museum of Comparative Zoology and in the author's collection. The adults were cut from the type gall collected by Couper about forty years ago.

The gall of this species was mentioned by Jarvis but the adults have not been described previously. The gall is a very simple and primitive sort of plant deformation, being more primitive than in most of the species of *Diastrophus*. *D. fusiformans* and *D. fragariæ* approach it in this respect. The adults are typical of the species of the genus and are readily separated by the key characters given in the description.

It is interesting to find another species of *Diastrophus* occurring on *Potentilla*. About half of the known species of that genus of gall-wasps are found on *Potentilla*, instead of being restricted primarily to plants of the genus *Rubus* as the first observations indicated. Thorough searching of the various species of *Potentilla* may disclose still other gall-wasps. Though *tumefactus* is known from only the one variety of plant, *norvegica*, which is confined mainly to the eastern part of Canada and the northern United States, it is possible that the same gall-wasp occurs on the typical

form of the plant, *monspeliensis*, which ranges from Alaska south into the District of Columbia and New Mexico. Or possibly still others of the larger-stemmed, shrubby species of *Potentilla* will have the same gall.

I also cut a parasite out of the gall—a species of Eurytomidæ.

***Neuroterus thompsoni*, new species**

Plate XXI, Figures 8 and 9

Neuroterus rileyi [error] THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 7, Pl. III, fig. 173.

FEMALE.—Almost entirely black, the antennæ ringed with light yellow at the second to third joint; length under 2.0 mm. **HEAD:** black, mouth-parts reddish brown; antennæ 13-jointed (inclined to curl in dried specimens), joints one and two stouter than the following joints though not as globose as in most species of *Neuroterus*, first joint dark brown, part of the second joint and the proximal tip of the third joint very light yellow, joints three to thirteen dusky brown-black. **THORAX:** piceous black; mesonotum microscopically cracked, without grooves; sides of the thorax lighter reddish black. **ABDOMEN:** piceous black, subpedicellate, rather angulate in outline; ovipositor apparently short. **LEGS:** light brownish yellow, the hind femora and tibiæ dusky brown except at the joints; tarsal claws almost black. **WINGS:** veins brown, the cubitus reaching the basal vein below the midpoint, the areolet rather large, the radial cell long, narrow, open. **LENGTH:** 1.7 mm.

MALE.—Differing from the female as follows: antennæ 14-jointed, uniformly yellowish; thorax reddish amber; abdomen elongate, pedicellate, yellowish brown, pedicel light yellow; legs uniformly yellow but with the tarsal claws black; length, 1.7 mm.

GALLS.—Pustulate swellings under the bark (Figs. 8 and 9), each swelling oval, about 2×3 mm., and elevating the bark about 1.0 mm.; usually many galls are confluent, around the twig and along it for a length of 2–12 cm. Larval cells, distinct but inseparable, lie in the wood, near the bark, 1–5 to each pustule, and each about 0.7 mm. in diameter. On young twigs of *Quercus prinoides*.

RANGE.—Massachusetts (M. T. Thompson Coll.).

COTYPES.—Twenty-three females, two males, and 6 galls, distributed in the collections of The American Museum of Natural History, the Boston Society of Natural History, of Mr. W. T. Davis, and in the author's collection.

The galls form in May.

Dr. M. T. Thompson mistook this material for *Neuroterus rileyi*, a middle-western species which *N. thompsoni* in general resembles, but the two are really quite distinct. *N. thompsoni* is only about half as large as the other species, both in the gall and the adult; the coloring of the antennæ and legs will distinguish *thompsoni*.

Through the kindness of Mr. C. W. Johnson, Curator at the Boston Society of Natural History, I have had an opportunity to study cynipid material in the Thompson Collection of galls and gall-insects. Though this collection was made in but a single season, the number of species therein represented is surprisingly large and is a credit to the thoroughness with which Dr. Thompson worked. I am glad to be able to give his

name to a species based on material of his own collecting. We shall profit considerably from the work he did and regret it was so prematurely stopped by his death in 1907.

***Andricus concolorans*, new species**

Plate XXII, Figures 12 and 13

Cynips cicatricula [gall] BASSETT, 1881, Can. Ent., XIII, pp. 101, 113. PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 57; 1890, 5th Report U. S. Ent. Comm., pp. 107, 109. ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 129.

Andricus cicatricula [gall] BASSETT, 1890, Trans. Amer. Ent. Soc., XVII, p. 80. DALLA TORRE, 1893, Cat. Hymen., II, p. 82. MAYR, 1902, Verh. Ges. Wien, LII, p. 289. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 62; 1910, Das Tierreich, XXIV, p. 542. VIERECK, 1916, Hymen. Conn., p. 413.

Callirhytis cicatricula [gall] BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 25.

Andricus cicatriculus [gall] THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 12, 31, Pl. III, fig. 171. FELT, 1918, Bull. N. Y. State Mus., CC, p. 79, Pl. I, fig. 1.

[*Andricus cicatriculus* (Bassett), male and female, belongs to *Ceroptres* Hartig, and is an inquiline in the gall of *Cynips concolorans*.]

FEMALE.—Mostly reddish piceous, the wing-veins very light amber, and antennæ and legs mostly rich golden brown. **HEAD:** piceous, the vertex almost black, coriaceous to finely rugose, the cheeks and face with a sparse, white pubescence; antennæ 14-jointed, uniformly rich golden brown, the third joint not much longer than the fourth. **THORAX:** piceous to black; pronotum striate, mesonotum finely and regularly shagreened, not heavily pubescent; parapsidal grooves continuous, fairly deep, well separated at the scutellum, sharply curving apart at the pronotum; median groove extending about one-third the way to the pronotum; anterior parallel lines smooth, shining, extending half-way to the scutellum; mesopleuræ striate, with a large shining area; scutellum black, finely rugose, sparsely pubescent, with the foveæ separated, not large, divergent, shining. **ABDOMEN:** reddish piceous, darker dorsally and posteriorly, second segment polished, extending almost to the tip of the abdomen; ovipositor sheaths extending above the tip of the dorsal line. **LEGS:** golden brown, all the coxæ and the hind femora and tibiæ darker; claws simple. **WINGS:** large; veins light amber; the cubitus very faint but extending well toward the basal vein; first abscissa of the radius angulate though not sharply so; the areolet moderately large; the radial area open. **LENGTH:** 1.3–2.2 mm.

MALE.—Similar to the female, but with the antennæ 15-jointed, the third joint curved; abdomen dark, slender, elongate; areolet small; length, 1.2–2.0 mm.

GALL.—Figs. 12 and 13. "Polythalamous galls on the midvein of the leaves of *Quercus alba*, [*Q. Prinus*, *Q. prinoides*, Thompson Coll.] never more than one on a leaf, and situated sometimes at the base, but usually from one-fourth to one-half way from the base, rarely above the middle. They project one-third below and two-thirds above the surface of the leaf. On the under side of the leaf they are rounded and on the upper cone-shaped. The gall is solid and somewhat fibrous, and in its shorter diameter measures about one-half inch and in the longer from five to seven-eighths of an inch. The larval cells radiate in all directions from the center of the gall and are quite numerous. There is at or near the summit of the cone a small scar or indentation...." Bassett, 1881, p. 101.

RANGE.—Massachusetts: Marthas Vineyard. Rhode Island: Providence (Thompson). Connecticut: Waterbury (Bassett). New York: Ellenville (in Coll. Amer. Mus. Nat. Hist.).

COTYPES.—Forty-five females, seventy-four males, in the collections of The American Museum of Natural History, the Boston Society of Natural History, the Museum of Comparative Zoology, in the author's collection, and elsewhere. The adult material was bred by Millett T. Thompson, No. 185 of his collection which is at the Boston Society of Natural History. The galls of the Thompson Collection are in poor condition, so I should designate my Marthas Vineyard material of galls as type galls for this species.

Thompson found the adults emerging late in June.

The type material of Bassett's *Andricus cicatriculus* in The American Museum of Natural History contains one female of *A. concolorans*, and a number of specimens of an inquiline. The description of the adult *cicatriculus* agrees with the inquiline to which that name must be applied; it would appear to be a *Ceroptres*. The material from the Thompson Collection matches the single female (undescribed) of the Bassett types. Thompson also bred the same inquiline.

Inquiline species are very often quite similar to their gall-maker hosts, and consequently most students of Cynipidæ have repeatedly described inquilines as true gall makers. But Homer F. Bassett was a careful enough worker to have avoided almost entirely such mistakes, and to find the instance here described lends emphasis to the fact that in *Andricus concolorans* and *Ceroptres cicatricula* the identity is unusually remarkable. The generic differences are quite apparent, but the specific details show few differences. The main points of difference, all generic (or even family) characters are:

	CYNIPID	INQUILINE
Radial cell	Open	Closed (not open as Bassett stated)
Radius, first abscissa	Angulate	Arcuate
Antennæ, female	14-jointed	13-jointed
Abdomen, first segment	Insignificant	One-fifth the length of the abdomen (separation from segment 2 not always visible)

The two species agree quite closely (though of course not exactly) in the following respects: general color of head, thorax, abdomen, antennæ (part), legs, wing-veins; length of body and of wings; sculpture of thorax (not exactly); relative prominence of wing-veins. This leaves very few specific characters of difference.

Contemplating such close resemblance of species of different genera, we are wont to consider again how such "mimicry" may have arisen. Mimicry among inquilines in cynipid galls is of especial interest because of the absence of anything like a struggle for existence between the two

organisms or an active struggle of these adults with any other organism. The inquiline usually reaches maturity and emerges from the gall, enjoying its first moment of a free or active life, some time after the brief adult life of the gall-wasp has been completed; often the inquiline does not appear until a half-year after the death of the gall-wasp. Since there is no meeting of the two adults and since there are practically no enemies of the adults of either species—nor could either adult offer any sort of resistance to an enemy, beyond that afforded by minute size, rapid running, or very feeble flight—it is hard to conceive of any advantage gained by the mimicry, and consequently hard to believe that natural selection has had any place in effecting the similarity. Nor is it possible that each species of inquiline has originated separately from its host species, for the differences, as pointed out, are largely generic or family characters.

I wish to note, without comment, that the larvæ of inquilines and hosts live in closely identical environments. Though the two do not usually come into actual contact and do not interfere in any way with each other, they do spend all but the very later part of their lives within a millimeter or less of each other and subsist most likely on the same sort of food—plant-cell contents, mainly sugars, or whatever it may be, supplied by the same individual plant and in the very confined and specialized part of that plant, the gall.

It has seemed worth noting this much, although I have not yet accumulated data enough to warrant generalizations. It would seem that with this group of insects there are conditions especially favorable for obtaining, by further observation and possibly through experiment, interesting evidence as to some factors producing some sorts of mimicry.

***Andricus furnaceus*, new species**

Plate XXII, Figures 14 to 16

FEMALE.—Head, thorax, legs, and antennæ reddish to dark piceous, abdomen reddish yellow; mesonotum deeply reticulate, entire thorax and legs covered with whitish hairs; cubitus not reaching the basal vein. HEAD: reddish, shading to piceous or black on the face, irregularly rugose and rather sparsely covered with yellowish hairs; head broadened behind the eyes, with the cheeks broad; antennæ uniformly reddish brown to reddish piceous, 14-jointed, the first joint broadly obconical, the third not much longer than the fourth, the following joints gradually shorter, the fourteenth joint one-third longer than the thirteenth. THORAX: dark reddish piceous, almost black on the scutellum, reddish piceous to black on the pleuræ and pronotum; the mesonotum rather deeply rugoso-reticulate, with a not sparse covering of yellowish white hairs, the sides of the pronotum and the metapleuræ more densely covered with longer hairs; parapsidal grooves deep, not especially convergent at the scutellum, and continuous to the pronotum; a pair of smooth, rather widely separated anterior parallel lines, slightly divergent anteriorly, extending half the way to the scutellum;

shallow but distinct lateral grooves extending almost parallel to the parapsides three-quarters of the way to the point where the parapsides meet the pronotum; median groove lost in the deep rugosities of the mesonotum; scutellum rather elongate, deeply rugose, hairy, with a very broad, rather deep depression at the base, with conspicuous, divergent ridges, but hardly defining distinct foveæ; mesopleuræ shallowly punctate, with long, appressed, yellowish hairs. ABDOMEN: reddish or yellowish red, brighter basally, smooth, with a few hairs at the sides of the second and on the edge of the third and following segments, the second segment somewhat projected dorsally to two-thirds the length of the abdomen; ovipositor sheaths short. LEGS: reddish brown to reddish piceous, shallowly punctate and entirely hairy, the tarsal claws toothed. WINGS: one-third again as long as the whole body, clear, regularly covered with short, dark hairs; all of the veins brown, the subcosta and radius the heaviest; areolet fairly large; cubitus not extending to the basal vein; radial cell open; the first abscissa of the radius curved very nearly at the midpoint to form an angle which is only a little greater than a right angle. LENGTH: 2.0-3.2 mm.

GALL.—A light grayish brown, rather regular swelling (Figs. 14 to 16) around small twigs, resembling a baked potato. Polythalamous, a single gall containing fifty or more larval cells. Usually a single, regular mass, rarely somewhat convoluted as though several portions had been fused; varying from a spherical to ovoid shape, usually somewhat concave where the twig enters the gall; 4.5×6.0 cm. or less in diameter; matted, light brownish gray in color, resembling the skin of a baked potato, with scattered flakes or patches of a loosened, dark brown, "burnt" skin. The whole interior is hard, compact-granular, with very little solid woody fibre; the larval cells average 2.5×4.0 mm., formed of a layer distinct from but closely embedded in the surrounding tissue, the cells scattered irregularly throughout the gall, but more abundantly nearer the center. Surrounding and surmounting the young twigs (preventing their further growth) of *Quercus* sp.

RANGE.—Mexico: San Luis, Potosi (Schaffner, Palmer Coll.).

CO TYPES.—Thirty-seven female and ten gall cotypes in The American Museum of Natural History, the Museum of Comparative Zoology, and in the author's collection. The insects were cut from one of the galls collected by Schaffner in 1880.

The same species was collected in 1878 in the same locality by Dr. Edward Palmer, and adults emerged from these galls in the summer of 1879.

This belongs to a group of several species from Mexico which are similar in coloring and general characters of pubescence, sculpture, wing venation, etc., and which produce, as far as known, similar galls which are large, woody swellings of twigs. Inasmuch as these species are so confusingly similar, it seems worth giving the following key for distinguishing them.

WOODY GALLS, MEXICAN SPECIES OF *Andricus*

1. Head or thorax or both with some reddish coloring, abdomen without any black; parapsidal grooves complete.....2.
- Head and thorax entirely black, ovipositor sheaths black; parapsidal grooves obliterated posteriorly.....*A. championi* Ashmead.

2. Cubitus continuous to the basal vein. 3.
Cubitus not reaching the basal vein. 5.
3. Length 3.5 mm. or more; foveæ at base of the scutellum are very large, broad, and rugose. 4.
Length 3.0 mm. or less; two small foveæ at the base of the scutellum; antennæ entirely rufous. *A. montezumus* Beutenmüller.
4. Antennæ dark rufous; median groove continuous; areolet very large; length 4.0–5.0 mm. *A. dugesi* Beutenmüller.
Antennæ with first two and last few joints bright rufous, the other joints almost black; median groove scarcely perceptible in the rugosities of the thorax; areolet only moderately large; length 3.5–4.2 mm. *A. peredurus*, new species.
5. Length under 3.2 mm.; thorax entirely hairy; no median groove, but deep and continuous parapsidal grooves; abdomen with hairs on the sides at the base. *A. furnaceus*, new species.
Length 4.0 mm.; median and parapsidal grooves indistinct; abdomen smooth (head and thorax not described as pubescent) *A. durangensis* Beutenmüller.

***Andricus incomptus*, new species**

Plate XXIII, Figures 17 and 18

FEMALE.—Mostly yellowish rufous, the antennæ shading into dark brown toward the tip; the tarsal claws brown; the areolet large, elongate; two clouded patches in the apical cell. **HEAD:** yellowish rufous shading into rufous brown on the face and on the tips of the mandibles; coriaceous, and moderately hairy; antennæ 13- or 14-jointed, yellowish rufous, the apical half becoming dark brown, third joint long and slender and fourth almost as long. **THORAX:** entirely yellowish rufous; mesonotum closely punctate, covered with moderately long, not very dense hairs; parapsidal grooves rather deep, converging at the scutellum, continuous to the pronotum; anterior parallel lines slightly elevated, extending half-way to the scutellum, but punctate similarly to the rest of the thorax and therefore indistinct in most lights; median groove lacking; lateral lines slightly elevated, almost smooth, somewhat darker than the rest of the thorax, and extending over half-way to the pronotum; scutellum long, cushion-shaped, rugoso-punctate, hairy, with two, very broad, moderately deep depressions at the base which, however, do not form distinct foveæ; pronotum punctate, hairy; mesopleuræ not entirely smooth, hairy, the upper third somewhat concave and rugoso-punctate. **ABDOMEN:** yellowish to brownish rufous, smooth and shining, as deep as long; second segment tongue-shaped, extending dorsally almost to the tip of the abdomen; hairy over the whole of the sides of the second segment, with a large tuft of long hairs at the tip of hypopygium. **LEGS:** yellowish rufous, slightly lighter than the rest of the body; tips of the tarsi dark brown, tarsal claws toothed. **WINGS:** veins brown, heavy; first portion of the cubitus, a cloud on the first abscissa of the radius, and two distinct, clouded patches in the apical cell yellowish; areolet large, quite narrow and elongate; the cubitus reaches the basal vein; radial cell open; first abscissa of the radius angulate, the angle obtuse. **LENGTH:** 2.5–3.2 mm.

GALL.—A mass (Figs. 17 to 18) of golden brown, straggling wool, containing a spherical core which is set with a dense, rich reddish-brown pubescence. Monothalamous. The covering hairs are 5 mm. or more in length, brittle, and rather wavy, forming an "uncombed" mass about 15 mm. in diameter. The central core is

spherical, averaging 7 mm. in diameter, and is covered with a very dense pubescence of dark reddish-brown hairs less than 1 mm. long; this covering is quite distinct from the longer, fewer hairs which form the main covering of the gall. The walls of the central core are almost 1 mm. in thickness, and the rest of the core is taken up with the large larval cell. Singly, or more often in groups of two, on the under surfaces (less often on the upper surfaces) of the leaves of a species of *Quercus*.

RANGE.—Mexico: San Luis, Potosi (Palmer Coll.).

COTYPES.—Two female and twenty-eight gall cotypes, in the Museum of Comparative Zoology, and in the author's collection, and cotype galls in The American Museum of Natural History. I cut the type females from the galls which were collected by Dr. Edward Palmer in September 1878.

The gall is very distinct. The character of the second segment of the abdomen and some other characters of the adult will place it in *Dryophanta* if that genus can be maintained. But for the time, until we have discovered the true lines of relationships, it seems best to describe the species under the meaningless name of *Andricus*.

***Andricus marmoreus*, new species**

Plate XXIV, Figures 22 to 24

FEMALE.—Mostly bright rufous, the sides of the thorax and coxæ piceous to black, the mesopleuræ irregularly coriaceous, the abdomen microscopically but completely reticulate. HEAD: yellowish rufous, darker on the face toward the bases of the antennæ, the tips of the mandibles piceous; irregularly and finely shagreened, with scattered hairs which are longest and densest on the extreme sides of the head and on the face toward the mouth-parts. Antennæ 14-jointed, hairy; joints one, two, and part of three light yellowish rufous, shading into the brown of the following joints. THORAX: mesonotum bright rufous with piceous or black on the very edges, rather regularly coriaceous, sparsely hairy; a median ridge from the scutellum to the pronotum being irregularly coriaceous, only slightly elevated, this becoming a depressed, smooth, very short groove at the scutellum; anterior parallel lines smooth, slightly elevated, and extending half-way to the scutellum; parapsidal grooves fairly deep, extending to the pronotum; lateral lines rather broad, rather smooth, neither elevated nor depressed, extending well forward toward the pronotum; scutellum bright rufous, piceous on the edges and the sides, cushion-shaped, deeply rugose, sparsely hairy, with the two deep foveæ at the base smooth, separated by only a very fine ridge; pronotum bright rufous to piceous, darkest anteriorly, irregularly rugose, sparsely hairy; mesopleuræ piceous to black, the upper third deeply and irregularly rugose, hairy, the lower two-thirds coriaceous, with a spot of rufous red, with few hairs which are longest and most dense at the lower edge. ABDOMEN: quite uniformly bright rufous red, somewhat darker at the posterior edge, very evenly and completely covered with a microscopic reticulation, with a few scattered hairs; the second segment large, covering most of the abdomen; the ovipositor sheaths very narrow and short, hardly as wide as an antenna, hairy. LEGS: coxæ piceous, femora rufo-piceous, tibiæ and tarsi yellowish rufous, the tips of the tarsi black, tarsal claws simple. WINGS: yellowish-tinged, quite hairy; veins brown, heavy, both branches of the cubitus fine and yellowish, a slight cloud on the basal vein and a prominent cloud around the apical portion of the subcosta and the first abscissa of the radius; areolet moderately large, almost an

equilateral triangle; cubitus not reaching the basal vein; radial cell open; the first abscissa of the radius angulate but without any projection into the radial cell, the angle formed being about 120° . LENGTH: 2.5–2.8 mm.

GALL.—A solid, marble-like gall (Figs. 22 to 24), mottled in color, about globular, and smooth, with a blunt tip. Monothalamous. The gall is 9 mm. or less in diameter, subspherical, somewhat flattened vertically, with usually a broad-linear tip at the apex 2–3 mm. long; the surface is light brown, not entirely smooth in dried specimens, the deeper portions colored darker, forming a speckled or evenly mottled design. The gall is solid, although the tissue is not compact, and contains a distinct but not separable larval cell which is about 3 mm. in diameter. Often in numbers, though not densely clustered, on the new shoots of *Quercus* sp.; the wedge-shaped base of the gall is inserted in deep slits in the twig, causing thin layers of the bark to flare slightly around the base of the gall.

RANGE.—Mexico: San Luis, Potosi (Palmer Coll.).

COTYPES.—Two female and fifty-eight gall cotypes in the Museum of Comparative Zoology and in the author's collection, and cotype galls in The American Museum of Natural History. The galls were collected in September 1878 by Dr. Edward Palmer, and I cut the cotype adults from those galls.

The gall is like a typical "bullet-gall" of the genus *Disholcaspis*, except that it does not have a separable larval cell. In anatomical characters the insect shows no relationship to *Disholcaspis*.

***Andricus mexicanus*, new species**

Plate XXIV, Figures 25 to 27

Cynips guatemalensis [galls] CAMERON, 1883, Biol. Centr. Amer., I, p. 71, Pl. iv, figs. 7, 7a. DALLA TORRE, 1893, Cat. Hymen., II, p. 70. DALLA TORRE and KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 60. DALLA TORRE and KIEFFER, 1910, Das Tierreich, XXIV, p. 446.

Andricus ? Mexicana [galls] BASSETT, 1890, Trans. Amer. Ent. Soc., XVII, p. 78.

Andricus mexicanus [galls] DALLA TORRE, 1893, Cat. Hymen., II, p. 91. DALLA TORRE and KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66; 1910, Das Tierreich, XXIV, p. 557. FELT, 1918, Bull. N. Y. State Mus., CC, p. 115.

?*Andricus mexicanus* [galls] THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 20, 33.

FEMALE.—Almost wholly bright reddish brown, generally pubescent; areolet large; abdomen covered with fine striations. HEAD: reddish brown, slightly darker toward the mouth, the tips of the mandibles dark brown; entire face with whitish, long, appressed hairs; compound eyes and ocelli shining black; antennæ dark yellow-brown, the second joint shorter than the first, the third as long as one and two and less than half as stout, the fourth little shorter than the third, remaining joints successively shorter, the whole antenna pubescent. THORAX: reddish brown, irregularly and slightly darker on a median line and on the sides, finely and regularly shagreened, with a whitish pubescence which is densest on the pronotum and the sides, parapsidal grooves well defined, extending to the pronotum, somewhat wider and converging toward the scutellum; no traces of anterior parallel lines or of a median groove; scutellum rugose, the foveæ shallow, broad, and separated by a very fine ridge. ABDOMEN: bright reddish brown, very finely shagreened, largely covered with fine striations and pubescent on the sides at the base; the second segment extending dorsally for two-thirds of the abdominal length. LEGS: quite uniformly yellowish

brown, the tips of the tarsi and the tarsal claws dark brown and toothed. WINGS: veins brown, the cross-veins, subcosta, and radius moderately heavy and dark brown; areolet large; cubitus fine but reaching the basal vein; radial cell open, first abscissa of the radius angulate. LENGTH: 2.7 mm.

GALL.—A large mass (Figs. 25 to 27) of wool, about hemispherical, 2.0–3.5 mm. in diameter, lemon-yellow to bright orange-brown; the hairs crystalline, brittle, forming a coating on the central core almost 10 mm. thick; the core polythalamous, of a dense, crystalline material, without separable larval cells. On the midvein, on the upper sides of leaves of an oak, *Quercus macrophylla* Nee? (Prof. Jack det.).

RANGE.—Mexico: "mountains near Guadalajara" (Bassett); Sierra de Nayarit, Jalisco (Diquet Coll.). Guatemala: San Geronimo (Cameron).

COTYPES.—Four females and nine galls, in the collection of The American Museum of Natural History, and in the author's collection. The galls were collected by Mr. L. Diquet in 1900, and deposited in the collection of the American Museum; the females were cut from the galls in January 1919, and consequently none of the insects are perfect specimens.

The gall is a splendid thing and must be very attractive if at all abundant in its range. The recorded stations are over one thousand miles apart, for apparently this is the same species of which Cameron and Bassett have described the gall, though neither obtained the adult. Bassett said that the host of his galls was probably *Q. crassifolia*. The insect belongs to the *Andricus-Callirhytis-Cynips* group of ill-defined genera.

***Andricus pellucidus*, new species**

Plate XXIII, Figures 19 to 21

[No name, gall only] OSTEN-SACKEN, 1873, Hayden Report U. S. Geol. and Geog. Surv., p. 567, No. 1.

FEMALE.—Mostly bright chestnut-rufous, the posterior portion of the abdomen rufo-piceous; thorax with distinct parapsidal grooves, but other lines essentially absent; wings with brownish patches in the apical cell, the radial cell short, rounded, clear, cubitus reaching the basal vein but without any thickening at the point of union. HEAD: bright chestnut-rufous, ocelli of the same color, mouth-parts slightly darker, compound eyes black; head very unevenly rugose, or variously sculptured, with a few whitish hairs; antennæ 14-jointed, mostly of exactly the same color as the face, but somewhat darker at the tips. THORAX: of the same chestnut-rufous color as the head (yellowish rufous in one specimen), the entire thorax quite uniformly colored or only slightly darker on the sides; mesonotum punctate, and with some other irregular sculpturing, and hairy; parapsidal grooves distinct, convergent at the scutellum, continuous to the pronotum; median groove absent, anterior parallel lines and lateral lines absent or with only faint traces discernible; scutellum small but elongate, irregularly rugose, sparsely hairy, with two large and broad foveæ at the base which are shining but rugose, only narrowly separated; pronotum irregularly rugose; mesopleuræ rugoso-striate with a small area which is almost smooth. ABDOMEN: smooth, shining, rufous, the posterior half, especially dorsally, a rich rufo-piceous, the second segment with a few scattered hairs basally and laterally, and a tuft of long hairs on the tip of the hypopygium; the second segment tongue-shaped,

produced dorsally for three-quarters the total length of the abdomen. **LEGS:** rufous, only slightly lighter than the thorax; tips of tarsi darker, quite hairy; tarsal claws toothed. **WINGS:** tinged with yellow, and covered with rather long yellow hairs, the veins dark translucent brown, the basal vein, distal half of the subcosta, and the radial veins darkest and heaviest; the areolet of moderate size or moderately large; the cubitus reaches or almost reaches the cross-vein (but without becoming brown and heavy at the point of union as in *Dryophanta bella* and *D. nubila*); apical branch of the subcosta almost lacking; first abscissa of the radius angulate, the apex of the angle being thickened and high up on the vein, almost at the point of union with the subcosta; second abscissa of the radius arcuate, making the radial cell broad and short; two or three irregular, rather indistinct, brownish patches in the apical cell, a trace of one in the discoidal cell, and a small, clouded spot on the discoideus not far from its union with the basal vein. **LENGTH:** 2.5–3.2 mm.

GALLS.—Globular (Figs. 19 to 21), smooth, dull or somewhat shining, thin-shelled, yellowish to pinkish, translucent galls, monothalamous, 8–15 mm. in diameter, empty except for a few, very fine, radiating fibers which hold the larval cell central in the gall; in size the larval cell is about 2×3 mm. On the under surfaces of leaves of a species of *Quercus*, attached to a vein.

RANGE.—Colorado: Colorado Springs (Carpenter Coll.).

COTYPES.—Eight female and eight gall cotypes in the collections of The American Museum of Natural History, the Museum of Comparative Zoology, and in the author's collection. One of the adults was bred; the others I cut from the galls collected by Lieut. W. L. Carpenter, September 25, 1873.

The material from which this species is described is that referred to by Osten Sacken in Hayden's report for 1873, the U. S. Geological Survey. Most of the adults had emerged from the larval cell but were found dead within the outer wall of the gall.

The gall is very pretty, being even thinner than the galls of *Dryophanta bella*, *D. dugesi*, and *D. rubra*, which it resembles. The insect, in having spotted wings, and in other respects, is similar to the adults of those same species, but is completely differentiated by the key characters given in the description. *A. pellucidus* belongs to a natural group containing the species mentioned above, *Dryophanta* (*Disholcaspis*) *centricola*, et al., and this is one of the groups which must be separated from other unrelated things now included in the genus "*Dryophanta*." Until complete revision of the cynipid genera can be made I give this species the meaningless name of *Andricus*.

***Andricus porodurus*, new species**

Plate XXV, Figures 28 and 29

FEMALE.—Head, thorax, and antennæ rufous and black, the abdomen reddish; thorax hairy and deeply reticulated; cubitus extending to the basal vein. **HEAD:** dark rufous, shading almost to black around the ocelli and mouth-parts; compound eyes black; whole head very rugose, with a covering of rather long hairs; antennæ 14-jointed, rufous black, the first two and the last four to six joints brighter rufous

these last six joints being subequal in length. **THORAX:** mesonotum bright rufous, piceous between the parapsides in their anterior parts, and piceous on the lateral grooves, deeply rugoso-reticulate, with rather long, rather dense yellowish hairs; parapsidal grooves deep, convergent at the scutellum, continuous to the pronotum where they are widely divergent; anterior parallel lines not entirely smooth, extending half the way to the scutellum; median groove evident but largely lost in the rugosities of the mesothorax; the lateral grooves distinct, smooth, and extending half the length of the thorax; scutellum black, somewhat rufous toward the elevated central area, deeply rugose, sparsely hairy, with a broad depression at the base which is similarly rugose, not defining entirely separate foveæ; pronotum and mesopleuræ rufous, shallowly punctate, covered with dense, closely appressed, long hairs. **ABDOMEN:** rich rufous-brown, slightly darker in places dorsally and toward the sides of the more posterior segments; hairy on the sides of all the dorsal plates, the hairs longest on the edges of the posterior segments. **LEGS:** bright rufous, the tibiæ very slightly darker except the hind tibiæ which are piceous or black; coxæ rufous; claws toothed. **WINGS:** very clear, only microscopically pubescent; veins brown, the areolet rather large, the cubitus not heavy but extending to the basal vein, the radial cell open, the first abscissa of the radius angulate, almost forming a right angle. **LENGTH:** 3.5-4.2 mm.

GALL.—A large, dark brown, irregular, woody mass (Figs. 28 and 29) surrounding a small twig. Polythalamous, often containing fifty or more larval cells. The whole is formed of very many distinct but thoroughly fused masses, forming a rather spherical gall 8 mm. more or less in diameter; the surface is very rough, completely cracked as though it were burnt leather, the raised portions polygonal, averaging 2 mm. in diameter, dark, blackish brown, the separating lines being much lighter or yellowish. Internally the gall is composed of a dense, somewhat granular tissue which becomes more compact-woody close to the margin and immediately around the larval cells. The gall is quite too hard to cut through with a knife. The larval cells are about 3 mm. in diameter, but elongate, and are closely surrounded by the woody tissue; they are scattered quite irregularly throughout the gall. Surrounding the young twigs of *Quercus* sp.

RANGE.—Mexico: San Luis, Potosi (Palmer Coll.).

COTYPES.—Ten female and three gall cotypes, in The American Museum of Natural History, the Museum of Comparative Zoology, and in the author's collections. The galls were collected in September 1878 by Dr. Edward Palmer; some of the adults emerged from the galls and others were recently cut out.

Dr. Hagen, who received these galls from Dr. Palmer, noted that pupæ and adults were alive in them in October 1879 and also in December 1879, i. e., almost a year and a half after the galls had been collected. It is likely that it is two or three years after the egg is laid before the insect reaches maturity. The tissue of the gall is about as hard as that of any gall I have examined. The species belongs to a group including several Mexican species which produce similar woody galls, and a key to separate these insects was included in the discussion of *A. furnaceus*, new species. The adult of this species shows some little variation in the shades of the colors.

***Andricus tecturnarum*, new species**

Plate XXV, Figures 30 to 33

FEMALE.—Mostly bright rufous, the tips of the antennæ and the posterior edge of the abdomen darker; hairy; foveæ at the base of the scutellum distinct, deep, smooth. **HEAD:** deep rufous, the mouth-parts only slightly darker; finely coriaceous, and hairy; antennæ 13-jointed (less often 14-jointed), rufous, hairy, the last one or two joints dark brownish. **THORAX:** entirely bright rufous, coriaceous, hairy; parapsidal grooves distinct, not very convergent at the scutellum, extending to the pronotum; anterior parallel lines rather smooth but not very distinct, extending half-way to the scutellum; median groove practically lacking but with a trace of a slightly differently colored median line; lateral lines distinct, rather broad, smooth, extending well forward; scutellum rugose, hairy, with the two foveæ at the base deep, smooth, divergent, almost at right angles, separated by only a narrow ridge; pronotum finely rugoso-punctate; mesopleuræ shining but very finely aciculate. **ABDOMEN:** shining rufous, darker posteriorly and dorsally, with a few hairs at the sides of the second segment and on the hypopygium; the second segment somewhat tongue-shaped, produced dorsally to cover two-thirds of the abdomen. **LEGS:** rufous, hairy, only the very tips of the tarsi dark; tarsal claws toothed. **WINGS:** veins brown, the second abscissa of the radius and the cubitus finer and lighter, with something of a cloud on the first abscissa of the radius; areolet not large; cubitus not quite reaching the basal vein; radial area open; first abscissa of the radius angulate. **LENGTH:** 2 mm. or slightly less.

GALLS.—Buff or reddish brown, woolly masses (Figs. 30 to 33) containing scores of closely clustered, hollow, urn-shaped galls. Each gall is monothalamous, about 10 mm. long by 3 mm. in diameter, consisting of a tube, which is rather conical, but compressed by contact with the other galls, thin-walled, crystalline, the upper half hollow and open at the end, a partition separating this space from a cavity which occupies the lower half of the gall and in which the larva lives. Each gall bears straw-colored to buff or reddish brown, crystalline hairs which are most dense near the summit, and which make of the cluster a single, oval mass often 35×25 mm. in size. The galls are all attached to the midribs, on the under surfaces of leaves of a species of *Quercus*.

RANGE.—Mexico: San Luis, Potosi (Palmer Coll.).

COTYPES.—Eight female cotypes and three clusters of galls, in the collections of The American Museum of Natural History, the Museum of Comparative Zoology, and in the author's collection. The galls were collected in September 1878 by Dr. Edward Palmer; some of the cotype adults were bred then from the galls, and others I cut out of the galls.

The individual galls are not unlike those of *Andricus crystallinus* or *Callirhytis tubicula* in structure, but they are entirely different in details of form and in being clustered in the large, woolly masses.

***Disholcaspis fungiformis*, new species**

Plate XXVI, Figures 37 to 39

FEMALE.—Antennæ 13-jointed, head and thorax bright reddish brown, black on the area between the anterior parallel lines, on the lateral lines, and in the foveal groove of the scutellum; abdomen dark rufous-brown. **HEAD:** bright reddish brown,

dark brown at the base of the antennæ and on the mouth-parts, coriaceous or finely rugose, the cheeks and the lower half of the face rather densely hairy; antennæ 13-jointed, hairy, brown, darker than the rest of the head, the first two joints stout and somewhat brighter in color. THORAX: entirely bright reddish brown except for a decidedly black area between the anterior parallel lines, around the lateral lines, and in the foveal groove at the base of the scutellum; mesothorax regularly punctate, at the sides rugose, covered with long, whitish hairs; parapsidal grooves deep and smooth at the scutellum, extending less than half the length of the mesothorax; median groove lacking; anterior parallel lines rather smooth and distinct, extending half-way to the scutellum; lateral lines broad, smooth, sinuous, extending beyond the middle of the thorax; scutellum cushion-shaped, rugoso-punctate, hairy, the foveal groove at the base well-defined, moderately deep, rugose, with a slight indication of a separation into foveæ; pronotum and mesopleuræ darker in color. ABDOMEN: rich, dark rufous-brown or reddish piceous, lighter at the base, shining, smooth except for a few, indistinct, irregular striæ at the posterior edges of the segments; patches of hairs at the base of the second segment at the sides, and a tuft on the tip of the hypopygium. LEGS: of the same color as the thorax, uniform in color, hairy; the tarsal claws toothed. WINGS: long, clear, the wing-veins yellowish brown, second cross-vein the heaviest, a slight clouding at the base of the first abscissa of the radius; areolet large, cubitus extending only a little more than half-way from the areolet to the basal vein; radial cell open; first abscissa of the radius angulate. LENGTH: 3 mm. or less.

GALLS.—A very curious cluster (Figs. 37 to 39) of brownish, mushroom-shaped, twig galls. Each gall is small, composed of three distinct parts: a solid top which is a broad, flattened cone 7–10 mm. in diameter but barely 4 mm. in height, the upper surface irregularly pitted, buff-brown, with the apex dark brown; a small, solid stem not 2 mm. in diameter and 2 or 3 mm. long connecting this cap with the base which contains the larval cell; a base which is a broad, inverted cone, the apex being the point of attachment on the twig, with an irregular, flaring, thin, leaf-like cup extending from this base up and around the cap of the gall, resembling an enormously developed cup at the base of a mushroom. Each gall is monothalamous, the larval cell occupying most of the basal part of the gall, the cell distinct from but tightly enclosed in the surrounding tissue. On the twigs of a variety of *Quercus virginiana*.

RANGE.—Texas: Tiger Mills, Burnett Co. (Schaupp); San Carlos (in Coll. Gray Herb.).

COTYPES.—Two females and several clusters containing over fifty gall cotypes, in the collection of the Museum of Comparative Zoology and in the author's collection, and gall cotypes in The American Museum of Natural History. I cut the adults from the galls which were collected by F. G. Schaupp in 1885.

The gall is the most curiously complicated structure I have seen among cynipid productions. It is possible that it is of quite a different form when young and fresh. I find additional specimens of these galls on oak material in the collections of the Gray Herbarium of Harvard University. This material was collected in November 1831 and is from San Carlos, Texas, which is over four hundred miles from the locality of the type material.

The general shape of this gall is very different from that of most of the species of *Disholcaspis*, but the location and character of the larval cell is typical for that genus. The insect is a true *Disholcaspis*.

Beside the two cotype adults from normal galls, I cut from a very small cotype gall a female which is in all respects like the cotypes but that it is generally darker and is very remarkably smaller in size, being only 1.7 mm. in length. I do not recall that I have ever before found an individual of the gall-wasps varying so from the average of length for the species.

Practically every one of the galls I have seen had large exit holes, indicating that a large number of the wasps had reached maturity and had emerged.

***Disholcaspis plumbella*, new species**

Plate XXVI, Figures 34 to 36

FEMALE.—Almost entirely bright reddish brown; antennæ 14-jointed; parapsidal grooves indistinct; anterior parallel lines close together; lateral lines prominent; second segment of the abdomen tongue-shaped. **HEAD:** light reddish brown, small spots near the ocelli and the tips of the mandibles dark brown; very finely granular-rugose, hairy; antennæ 14-jointed, joints one and two stout, third joint long and slender, whole antenna quite uniformly reddish brown, pubescent. **THORAX:** bright reddish brown, only very slightly darker on the parallel lines and the lateral lines; mesothorax much elevated and rounded, as broad as long, finely coriaceous, covered with rather long, yellowish hairs which are shortest and less dense on the midline; parapsidal grooves not very distinct, extending half-way to the pronotum; median groove mostly absent; anterior parallel lines prominent but not smooth, unusually close together, extending more than half-way to the scutellum and diverging slightly posteriorly; lateral lines prominent, free of hairs, not smooth, extending from the scutellum half-way to the pronotum; scutellum finely rugose, hairy, with two large foveæ at the base, shining, but somewhat rugose. **ABDOMEN:** rufous, darker posteriorly, shining but finely punctate, the sides entirely covered with rather long hairs, the second segment tongue-shaped, i. e., produced dorsally. **LEGS:** coxæ of the same color as the thorax. **WINGS:** clear, the veins yellowish brown. **LENGTH:** about 3 mm.

GALLS.—Small, brown, bullet-galls (Figs. 34 to 36), bearing a sharp, projecting point at the apex. Monothalamous. Entirely spherical, 9 mm. or less in diameter, yellowish or reddish brown, the surface of the dried galls shrivelled but essentially smooth, bearing a sharp point at the apex which is about 1.5 mm. long. Internally the gall is filled with a loosely granular, yellow tissue; the larval cell is hardly distinct from this surrounding tissue. On twigs of *Quercus dumosa*.

RANGE.—California: San Diego County (D. Cleveland Coll.).

COTYPES.—A female holotype and three gall cotypes in the collection of the Museum of Comparative Zoology and in the author's collection. The galls were collected in October 1875. The adult which I cut from one of these cotype galls is broken and imperfect.

The galls were sent to the Baron Osten Sacken by D. Cleveland. They are typical of galls of the genus *Disholcaspis* except that the larval cell is hardly distinct from the surrounding tissue; and the adult is likewise a true *Disholcaspis*, although the shape of the second segment of the abdomen is similar to that found in the species included in *Dryophanta*.

***Disholcaspis pruniformis*, new species**

Plate XXVII, Figures 44 and 45

FEMALE.—Generally light reddish brown, black between the anterior parallel lines, on the lateral grooves, and on the transverse groove at the base of the scutellum; antennæ 13-jointed; areolet moderately large. **HEAD:** bright reddish brown, darker between the bases of the antennæ and toward the mouth-parts, slightly and finely rugose, with long hairs which are much less dense on the front. Antennæ darker brown, 13-jointed, pubescent. **THORAX:** mesonotum bright reddish brown, black on and between the anterior parallel lines and on and about the lateral grooves, dark brown in the parapsidal grooves; regularly punctate and dense with a long pubescence; parapsidal grooves wide, deep, and convergent at the scutellum, narrowing and disappearing half-way to the pronotum; anterior parallel lines smooth and extending half-way to the scutellum; lateral lines broad, smooth, and extending a little more than half the length of the mesothorax; scutellum rufous brown, rugose, with a long pubescence, the transverse groove at the base broad, quite deep, black, rugose; metapleuræ densely pubescent; pronotum and mesopleuræ reddish brown, punctate, with a long pubescence, the pronotum black anteriorly. **ABDOMEN:** yellowish to reddish to dark brown, lightest laterally, the entire second segment, the seventh segment, and the tip of the hypopygium hairy; the abdomen is large, but the second segment is very small converging only about one-third of the abdomen; segments three to seven are broadly visible and subequal. **LEGS:** reddish brown, including the coxæ, part of each femur and the whole of each tibia darker brown; punctate, pubescent; claws with a large tooth at the base. **WINGS:** clear, microscopically but densely pubescent, the veins dark brown, the subcosta and cross-veins darkest in color; areolet rather large, cubitus extending only two-thirds of the distance to the basal vein; the radial cell broad and widely open, the first abscissa of the radius somewhat suffused with brown and angulate, the angle about 120° and with its apex above the midpoint of the vein. **LENGTH:** 3.5–4.0 mm.

GALLS.—About the size and shape of a small plum (Figs. 44 and 45), yellow to reddish brown. Monothalamous. Somewhat elongate, broadest nearer the apex, more pointed toward the base, about 2.8×2.1 cm., light yellowish brown, broadly tinged with reddish brown, most likely entirely smooth while alive, but the thin skin becoming slightly rough by shrivelling on drying. Internally filled with a compact, not solid mass of yellowish, crystalline, sawdust-like material, only slightly approaching a woody fiber structure around the larval cell which is central in the gall, thick-shelled, and closely imbedded (at least in the dried gall) in the surrounding tissue. Attached on the side of the young twig, at the one-year node, on "post-oak."

RANGE.—Texas: Tiger Mills, Burnett Co. (Schaupp Coll.).

COTYPES.—Three female and two gall cotypes in the collection of the Museum of Comparative Zoology, and in the author's collection. Number 42 of the Schaupp Collection made in 1884.

The galls, though bearing separate numbers, had been placed together with galls of *Amphibolips ginesi*, and the galls of the species are superficially similar, but the gall of *D. pruniformis* differs in not being perfectly round and in being colored yellowish and reddish brown. The adults are typical of the species of *Disholcaspis*. They agree closely with the description of *D. heynei* Kieffer which was described (1910, Boll. Lab. Zoo. Gen. e Agr. Portici, IV, p. 113) from the adult only. They are to be distinguished from that species by their smaller size, by being bright reddish brown in color (*heynei* is described as rufous with the abdomen blackish brown), by showing a broad transverse groove at the base of the scutellum (this is narrow and indistinct in *heynei*), by having toothed claws (*heynei* was described as having "crochets simples"), and by details of thoracic configuration and wing venation. *D. pruniformis* has a smaller second abdominal segment than most species in the genus.

***Disholcaspis unicolor*, new species**

Plate XXVII, Figures 40 to 43

FEMALE.—Wholly golden rufous, without any black markings on the thorax or abdomen; median groove lacking; anterior parallel lines indistinct; a distinct foveal depression at the base of the scutellum; cubitus not reaching the basal vein but extending seven-eighths of the way to it. **HEAD:** bright golden-rufous, the tips of the mandibles piceous, rugoso-punctate, hairy, irregularly striate toward the mouth; antennæ hairy, golden rufous, shading into a brown on the last joints. **THORAX:** entirely golden rufous (without the black markings characteristic of *D. cinerosa*), punctate, covered with rather long, appressed hairs; parapsidal grooves deep, smooth, broad and convergent at the scutellum, becoming narrow and disappearing on the middle of the thorax; median groove entirely lacking; lateral grooves distinct, smooth, almost parallel with and as long as the parapsidal grooves; anterior parallel lines almost as punctate as the rest of the thorax and therefore not visible in most lights; scutellum large, rugose, hairy, with the deep foveal depression at the base less rugose and hairy than the rest of the scutellum and therefore distinct; pronotum punctate, very hairy, the hairs long; mesopleuræ less closely punctate than the rest of the thorax, hairy; metapleuræ largely golden rufous (not dark rufous or piceous as in *D. cinerosa*). **ABDOMEN:** large, uniformly golden rufous, the sides of the second segment, and the tip of the hypopygium hairy. **LEGS:** entirely golden rufous, hairy, the tips of the tarsi, especially of the hind tarsi, darker or brown; tarsal claws toothed. **WINGS:** with the microscopic hairs brown, the veins brown, the cross-veins heaviest; areolet large, almost a right-angled triangle; the cubitus not reaching the basal vein but extending seven-eighths of the way toward it; radial cell open; first abscissa of the radius angulate. **LENGTH:** 4.2 mm.

GALLS.—Large, globular bullet-galls (Figs. 40 to 43) with a nipple at the apex; rough, with a mealy covering when younger. Monothalamous. 21 mm. or less in diameter. Buff-brown in color when young, dark gray or black when old. Internally quite filled with a solid, woody tissue, the thick-shelled, egg-shaped larval cell separable but tightly enclosed in the younger gall, lying loose in a good-sized cavity in the mature gall. On the twigs of a species of *Quercus*, singly, or several near together.

RANGE.—Mexico: Saltillo Mts. (Palmer Coll.).

TYPES.—A female holotype in the Museum of Comparative Zoology, and 21 gall cotypes, in the collections of the Museum of Comparative Zoology, The American Museum of Natural History, and in the author's collection. The galls were collected in August 1879 by Dr. Edward Palmer; I cut the female from the galls.

Except for its more woody tissue internally, the gall of this species seems quite identical with the gall of *Disholcaspis cinerosa* (Bassett, 1881, Can. Ent., XIII, p. 110), which is known from Texas only. The adult, though very closely related to *cinerosa*, is really very distinct and readily distinguished from that species by the key characters I have given at the beginning of the description of this species. I have examined a large series of adults of *cinerosa* and do not find that it varies toward *unicolor*.

PLATE XX

- Fig. 1 *Andricus punctatus*, normal gall, $\times 1$.
Fig. 2. *Andricus punctatus*, parasitized gall, $\times 1$.
Figs. 3 to 5. *Aulacidea annulata*, new species, $\times 1$.

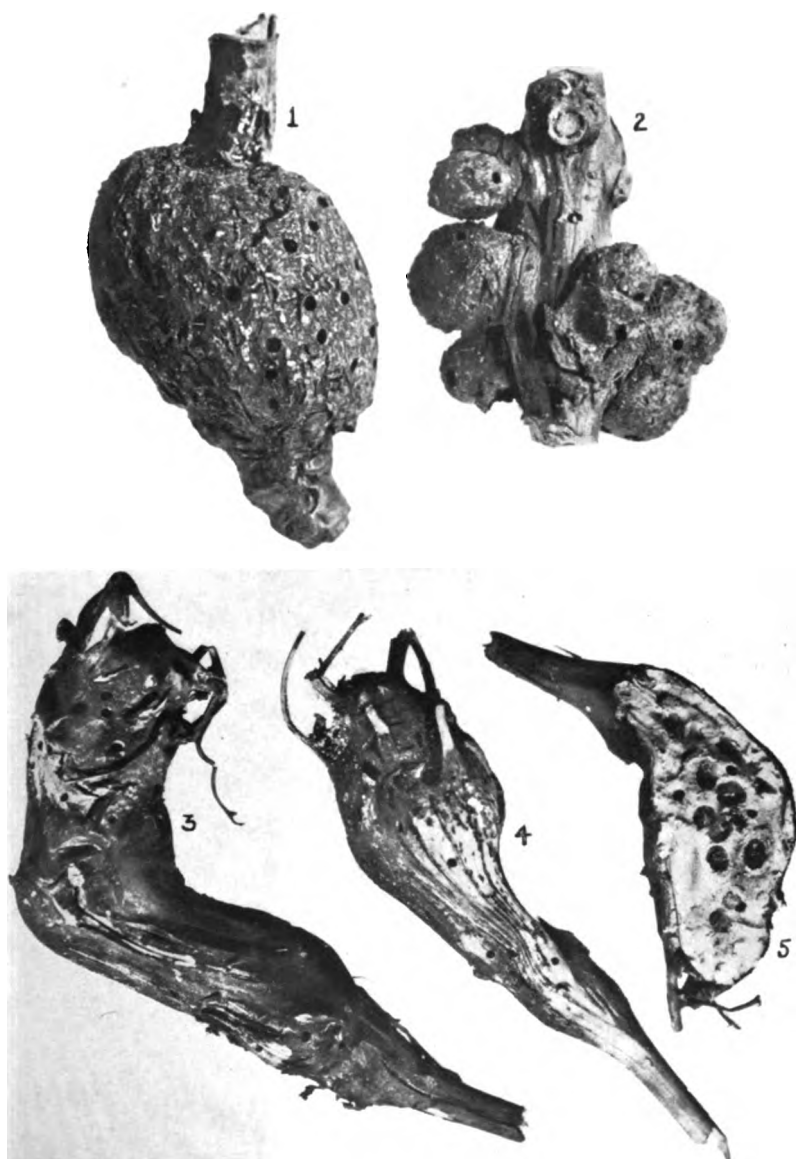


PLATE XXI

- Figs. 6 and 7.** *Aulacidea abdita*, new species, $\times 2$.
Figs. 8 and 9. *Neuroterus thompsoni*, new species, $\times 4$.
Figs. 10 and 11. *Diastrophus tumefactus*, new species, $\times 2$.

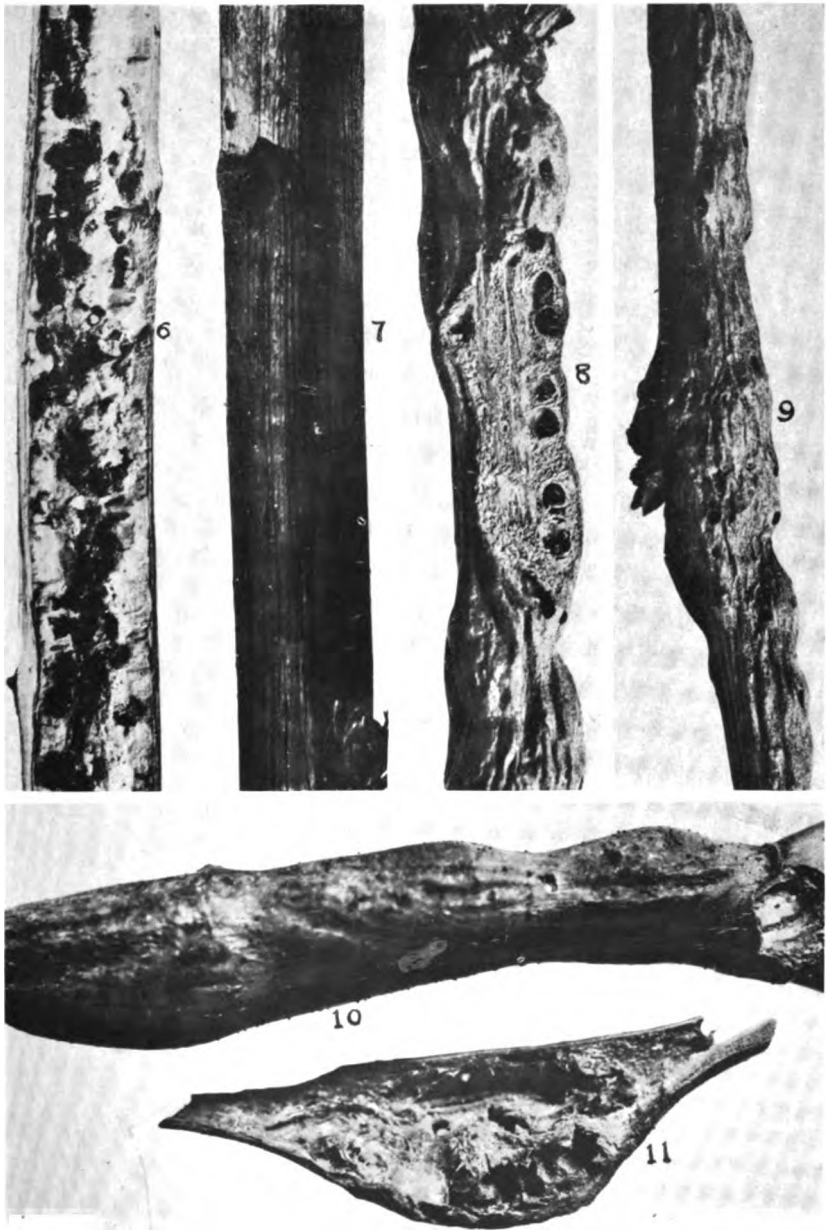


PLATE XXII

Figs. 12 and 13. *Andricus concolorans*, new species, $\times 3$.
Figs. 14 to 16. *Andricus furnaceus*, new species, $\times 1$.

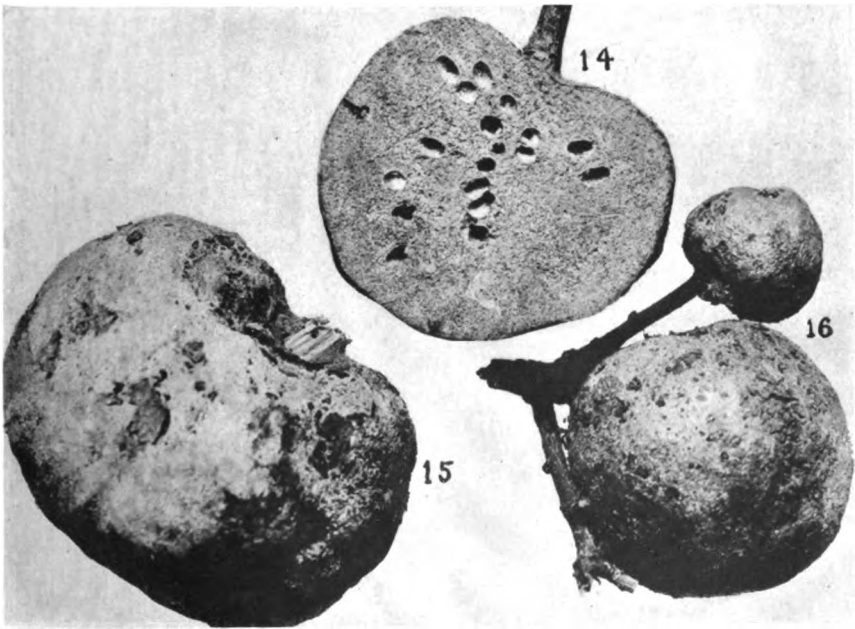
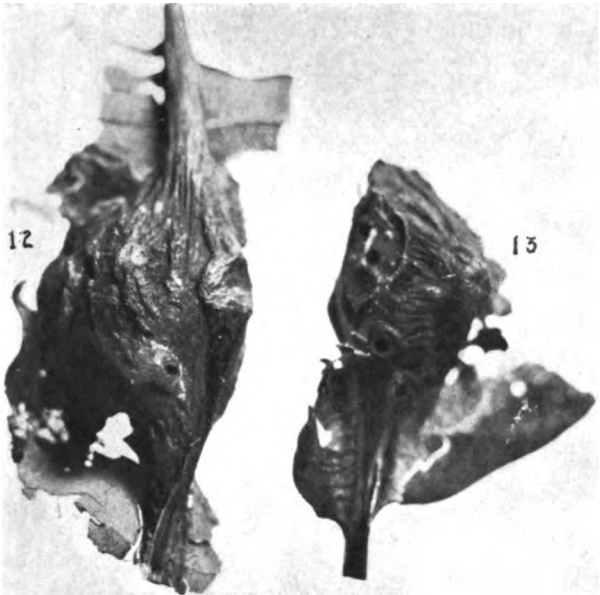


PLATE XXIII

Figs. 17 and 18. *Andricus incomplus*, new species, $\times 2$.
Figs. 19 to 21. *Andricus pellucidus*, new species, $\times 3$.

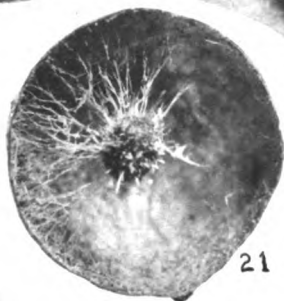
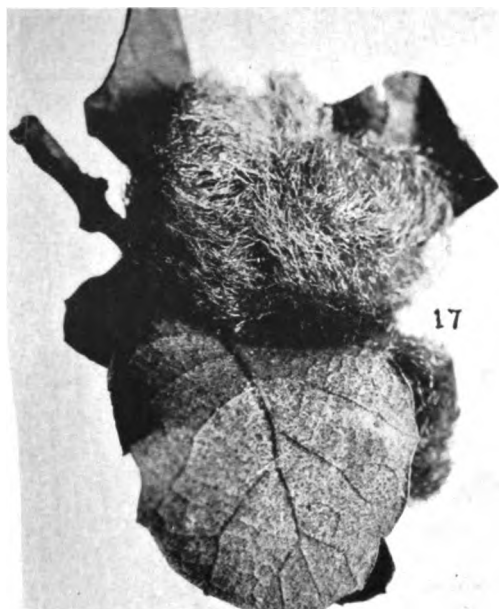


PLATE XXIV

Figs. 22 to 24. *Andricus marmoreus*, new species, $\times 2$.

Figs. 25 to 27. *Andricus mexicanus*, new species, $\times 2$.

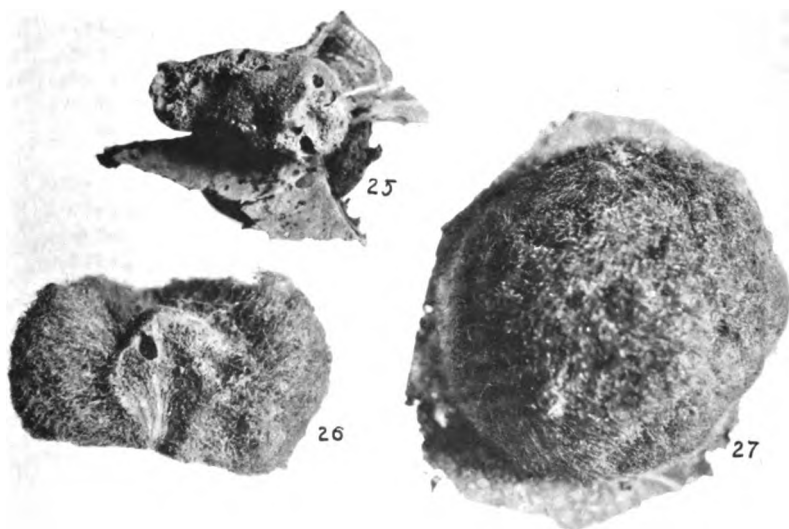


PLATE XXV

- Figs. 28 and 29. *Andricus peredurus*, new species, $\times 1$.
Figs. 30 and 31. *Andricus tecturnarum*, new species, $\times 2$.
Figs. 32 and 33. *Andricus tecturnarum*, new species, $\times 4$.

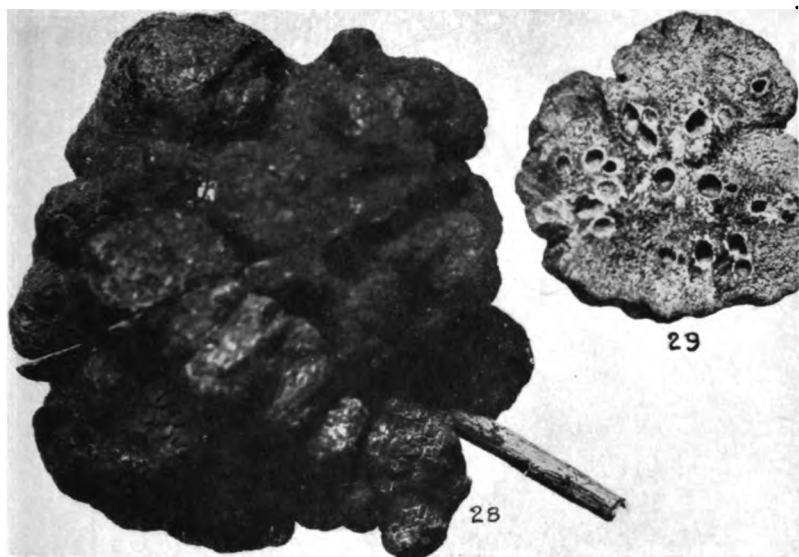


PLATE XXVI

- Figs. 34 to 36.** *Disholcaspis plumbella*, new species, $\times 2$.
Fig. 37. *Disholcaspis fungiformis*, new species, $\times 2$.
Figs. 38 and 39. *Disholcaspis fungiformis*, new species, $\times 4$.

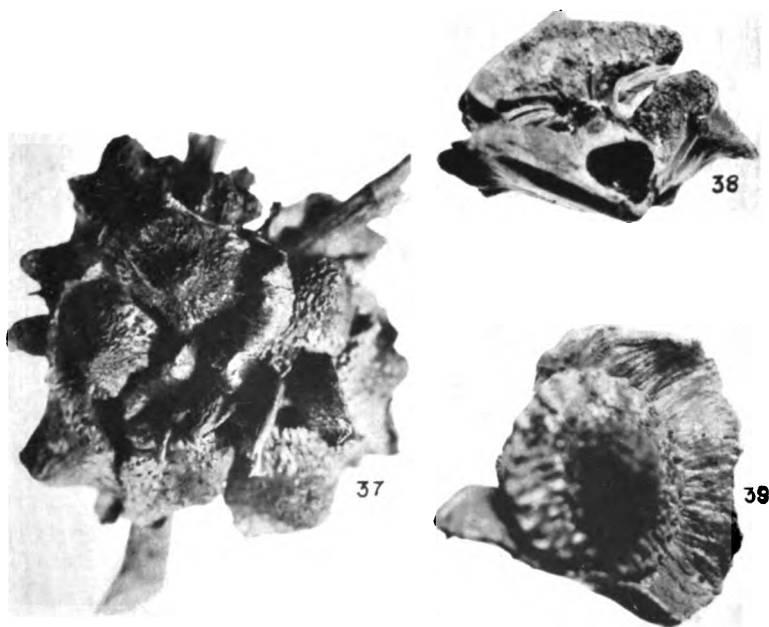
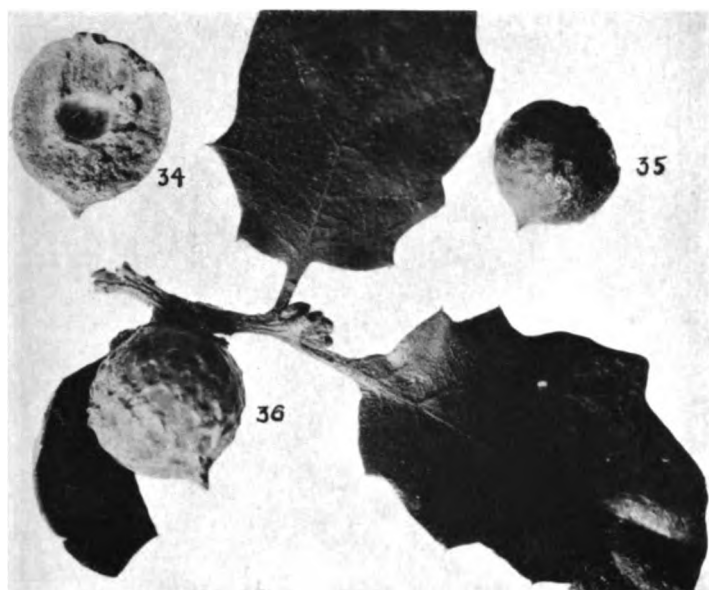
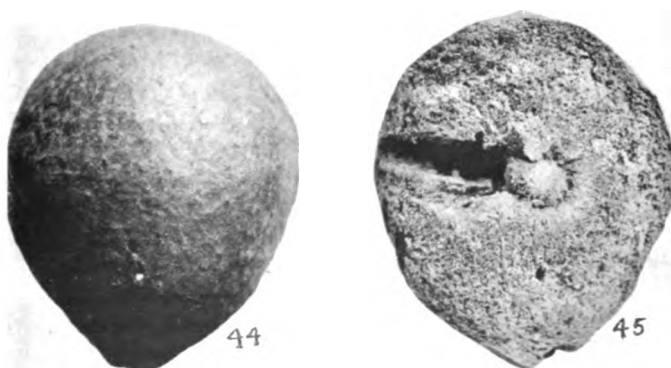
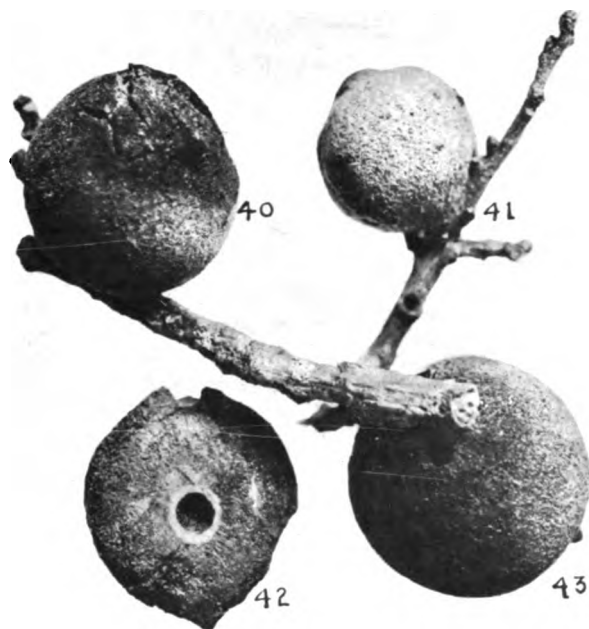


PLATE XXVII

Figs. 40 to 43. *Disholcaspis unicolor*, new species, $\times 2$.

Figs. 44 and 45. *Disholcaspis pruniformis*, new species, $\times 2$.



Article VI.—LIFE HISTORIES OF AMERICAN CYNIPIDÆ¹

BY ALFRED C. KINSEY

PLATES XXVII to XXXI

CONTENTS

	PAGE
INTRODUCTION.....	319
METHODS.....	320
HISTORICAL.....	323
LIFE HISTORIES.....	326
<i>Aylax glechomæ</i> (Linnæus).....	326
<i>Rhodites rosæ</i> (Linnæus).....	328
<i>Rhodites ignotus</i> Osten Sacken.....	331
<i>Neuroterus balatus</i> (Fitch).....	333
<i>Neuroterus noxiosus</i> (Bassett).....	336
<i>Neuroterus lectus</i> Bassett.....	338
<i>Andricus futilis</i> (Osten Sacken).....	341
<i>Andricus operator</i> (Osten Sacken).....	345
<i>Andricus palustris</i> (Osten Sacken).....	348
<i>Andricus fulvicollis</i> (Fitch).....	353
BIBLIOGRAPHICAL NOTE.....	357

INTRODUCTION

It is generally known that the peculiar biological phenomena of gall production, agamic reproduction, and heterogeny occur among the Cynipidæ (Hymenoptera); and a study of the life histories of a larger number of the species may reveal still other peculiar biological characters or will certainly show modifications of phenomena as they are known today which will furnish especially interesting information. The amount of work involved in solving these life histories is rather considerable, and to study any number of the five hundred or more American species of gall-wasps will call for the help of many students. It is to furnish a ready equipment to those who care to undertake such work, as well as to make available for general use a body of data, that I shall gather in this and subsequent papers the available facts concerning the species of which the life histories are known. Some of these have not previously been known. The accounts of the life histories of most of the others bring together for the first time information that has been scattered through a wide range of literature, much of which has not been available to the general student. It is my aim to supply complete bibliographies, redescrptions of adults

¹Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 164.

and galls, detailed records of distribution, etc., and all the biological data available for each species.

The nomenclature adopted needs a word of explanation. Because of the poor distinction of several of the genera of the oak gall makers, it seems unwise to employ the generic titles *Cynips*, *Callirhytis*, *Philonix*, etc., until a careful revision of the genera of the family has been made. For that reason, I have used the name *Andricus*, the most meaningless of all these titles, with a number of the forms.

To distinguish the alternate generations of a species, I have had to adopt a new form of naming. It is highly unreasonable to continue to use the names given independently to each generation before the connections of the two forms were understood. It is very inconvenient to use a single binomial to cover the species and to designate the generation referred to by some phrase such as "agamic generation," etc. These are the methods at present in use in Europe in naming these insects. I have adopted trinomials. Trinomials have been used previously to distinguish the forms of species showing a seasonal dimorphism; and, as I am showing elsewhere, alternation of generations among the Cynipidæ is merely seasonal dimorphism developed to an extreme degree in certain instances. So we seem warranted in adopting the sort of nomenclature employed in other cases of seasonal dimorphism. Such a system has the important advantages of retaining the well-known names for each form of the insect, but the name is combined in a way to indicate the complete specific relationships.

I am indebted to many persons who have helped me in this work. Dr. Frank Lutz of The American Museum of Natural History, Charles W. Johnson of the Boston Society of Natural History, and Nathan Banks of the Museum of Comparative Zoology have been liberal in allowing me to examine cynipid material in the collections of which they are in charge. Dr. William M. Wheeler, Professor Charles T. Brues, and Professor Irving W. Bailey, of the Bussey Institution of Harvard University, have constantly encouraged my work, and to them I am especially indebted. To Professor Brues I am further indebted for the remarkable plates with which this paper is illustrated and which are very important aids in showing the characters of the alternate generations.

METHODS

For those who will pursue further the study of life histories of Cynipidæ, much time may be saved by a description of the methods I have found to be the most satisfactory for this work. My methods have been similar to those used by Adler but involve some modifications.

Galls are best collected not too long before they reach maturity. Only experience with each species, involving continued observation of specimens of the galls, and obtaining of such information as may be supplied by the size of the gall, the degree of development shown by the insect within the gall, etc., can supply information of the approach of the emergence date for a particular species. Most of the solid, hard, woody, or dry-shelled galls may be kept successfully for many months, but the adults of soft, spongy, or hollow, succulent galls cannot be raised if the galls are gathered more than a week or even a few days before the insects are due to emerge.

Sufficient care is not usually exercised to keep separate the several species collected at any one time. Confusion as to the species of the host plant from which the gall was obtained and the hopeless confusion of any adults that may emerge from the galls before they are finally sorted are the results of putting galls of several species into a single receptacle. A large part of museum material is rendered worthless by such methods of collecting. Paper bags of several sizes are readily available means of separating the galls in the field but, if extensive collecting is to be undertaken, it is preferable to make cloth bags, which are much stronger, take up less room, and may be more securely tied at the top than paper bags.

Undoubtedly the most satisfactory means of rearing the adult wasps is to place the galls on an inch or more of moist sand in a low glass jar at least four or five inches in diameter. The moisture thus supplied keeps the galls from drying out and dying; but the galls should not be piled in too deeply or those on top will not mature and those on the bottom will rot. The glass may be covered with cloth fastened on by an elastic band (which does not wear out-of-doors), or tied with twine (which is less convenient if it is desirable to open the jars a number of times). The jars must be broad and low, and should be kept out-of-doors, under some shelter but where the normal temperature and an abundance of air and wind will prevent mold from developing. Indoors, mold is almost certain to prove a problem. The use of earthen flower pots prevents too much moisture accumulating in the sand, and such receptacles for that reason are preferable to glass jars, but in the pots the emergence of the insects is not so easily observed. Galls that are to be kept over winter or for a long time before the insect matures may be kept in earthen pots until the approach of the date of emergence.

The growth of the galls under controlled conditions should be effected on plants growing in cultivation and kept from possible attack

by wasps from other than the bred material, either by distance from any other plants of the sort (the Cynipidæ almost never fly and most likely never travel more than a very short distance), or by a shelter or covering. It is not desirable to have the plants indoors, for they do not develop at normal rates under these abnormal conditions and the insects will not attack the plants unless they are at the proper state of development. Wild roses and blackberries are easily transplanted, but it is profitable to secure nursery-grown oaks of several species, four or five years old, for the work. These should be growing thriftily before experiments are started, or else galls will probably not be obtained. To wait a year or so after the trees are transplanted is one of the almost necessary problems presented by the work.

If the alternate generation of a species which is being studied is to lay its eggs in the flowers or acorns of the oak, recourse must be had to older trees growing in the open, such additional precautions then being taken as will insure as far as possible the immunity of the part of the tree used from attack by any other gall-wasps than those under observation. Some species will oviposit in the roots of trees. These will be detected instantly, for they are positively geotropic and will start immediately to climb down the tree. These forms, while in the breeding jars, should be placed at the bases of trees having living roots near the surface and covered by only a very little loose earth or, better, leaf-mold, and which have the covering nets extending entirely to the ground, into which the cloth is pegged.

When the insects have emerged within the breeding jars, the trees should be covered with net bags. I employ large cylinders made of a closely-woven cheese-cloth, the cylinder open at the bottom and kept in shape by two heavy wire rings of the same diameter as the cylinder and sewed into place, one in the closed end of the bag and the other about a foot from the open end. These cylinders should be large enough to cover a large part of the tree or even the whole tree, for then the insects are given greater freedom in the choice of the spot for oviposition. Tapes sewed to the closed end of the bag will hold it to some beam or other support above the tree. A strip of sheet celluloid may be fastened into the cloth by a waterproof solution (a few drops of castor oil added to sheet celluloid dissolved in acetone) and the window thus supplied is a great convenience for observing the insects ovipositing. The breeding jars may be placed on wooden blocks or other supports on the ground at the base of the tree, the net drawn down to include the jars, the open end of the net brought together and securely fastened around the main

stem of the tree, and then the covers worked off of the breeding jars. The insects are thus placed on the tree and confined immediately upon emergence from the galls. The nets may be left on the trees for three or four weeks, thus insuring quite completely that no other gall-wasps may attack that tree, but to keep the tree covered for a longer period will usually affect the vigor of the plant and prevent the growth of the galls. Adler, in working out the life histories of European cynipids, employed only smaller coverings for the trees, but by the use of nets large enough to cover the entire tree it is possible to give a much wider range of activity to the insect; and by placing the breeding jars directly into the nets the danger of injuring these delicate insects by handling is entirely avoided.

The adults of most species of cynipids have very little vitality, and to effect oviposition they must usually reach the part of the plant in which the egg will be laid within a few hours after emerging from the gall. Insects kept a couple of days after emergence rarely have vitality enough left to lay eggs. The occurrence of a rainy or even foggy day at the time of emergence of a species (most of the adults of any particular species will emerge within a very few days of each other) will prevent immediate oviposition, and by the time the weather has cleared the insects have lost all vitality and will not attempt to climb over the trees. In spite of all care, to obtain galls experimentally is a difficult process, often proving unsuccessful. From about two thousand gall-wasps placed upon plants the first year of my work, when the trees were newly transplanted and not growing very vigorously, I secured only twenty galls. The factors influencing the growth of these deformations are hardly at all understood, but it is very likely that the trees on which they are to grow must be in very vigorous condition. An abundance of insects of any one species will usually be necessary to secure any amount of results.

HISTORICAL

The alternation of two quite different forms in successive generations of an organism was discovered first in 1819 by Chamisso in a tunicate of the genus *Salpa*. "A *Salpa*-mother is not like its daughter or its own mother, but resembles its sister, its granddaughter, or its grandmother" was a remarkable statement to hear in a day when spontaneous generation theories had only recently been widely discarded and when the resemblance of all offspring to their parents seemed the foundation stone of biological science. Though plenty of other observations soon confirmed Chamisso's discovery, it was not until the time of the extensive observations of Lichtenstein with aphids and of Adler with Cynipi-

dæ that it was realized that alternation of generations is a wide-spread phenomenon. The very diverse forms of the alternate generations of many species of gall-wasps and the apparently regular succession of the agamic with the bisexual forms, which constitutes true heterogeny, are not known to be equaled in any other large group of highly developed animals and, consequently, unusually wide attention has been attracted to life histories of gall-wasps.

The discovery of heterogeny in the Cynipidæ dates from an observation reported in 1864 by Homer F. Bassett, librarian in the town of Waterbury, Connecticut, and a student whose long series of observations of gall-wasps were made with a degree of painstaking care unmatched by any other worker with the family. Bassett reported as follows (1864, Proc. Ent. Soc. Philadelphia, III, p. 198):

The flies [of *C. q. operator* O. S.] have now nearly all appeared [from woolly galls on the buds and aments] and I have watched them carefully to learn if possible whether the females deposited any eggs, and if so, whether they are deposited in the young leaf-buds.

I have reared thousands of the flies and have seen thousands more within a few days on the leaves of the shrub-oak, but have not been able to find any in the act of ovipositing until this afternoon.

On visiting a shrub-oak (*Q. ilicifolia*) thicket this afternoon I found *hundreds* of *C. q. operator* with the *ovipositor*, (nearly twice the length of the body) *inserted the full length into the cups of the young acorns*. [Etc. in detail.]

That you may see that I am not mistaken, I send you with this a few acorns with the fly still attached. They were killed by immersing in boiling water.

To find a gall-wasp depositing its eggs at a spot which could not possibly have produced a gall similar to that from which the insect had emerged would, at the date of Bassett's first observation, have been passed by as mere delusion by observers less careful. Three years earlier Osten Sacken (1861) had suggested that the species of cynipids known in the female sex only might have the male developed in other kinds of galls, but the theory was quite without proof and could not have been of much encouragement to Bassett, even had he known of Osten Sacken's obscure paper. Bassett made no prediction or theory concerning the curious fact he had discovered.

In 1873 Bassett wrote again: "I have, for the past three years, carefully examined the buds of *Q. ilicifolia*, hoping to find the producer of *C. q. operator* at work, but without success, till this week, when I found no less than thirty gall flies ovipositing in the buds of this oak." Bassett had then discovered the insect which oviposited to produce the woolly gall and the galls produced by the insects from that woolly gall. It only remained to prove that insects from the second form of the

gall, the acorn-gall, were identical with those which had been found ovipositing to produce the woolly gall. This connection was finally established when C. V. Riley, in the spring of the same year in which Bassett found the producer of *C. operator*, bred the adult from the acorn-gall. It was identical with the producer of *C. operator*. The fact of alternation of generations in the Cynipidæ was thus completely proved.¹

Meanwhile, B. D. Walsh (1864) had reported in great detail the discovery of two very different forms of adults, one agamic and the other bisexual, emerging at different times of the year from very similar if not identical galls of *Amphibolips confluens*. The work was undoubtedly exact as far as it went and, if it covers the complete life cycle of the species, it furnishes the first completed record of alternation. But Walsh, though he attempted to control the insects by confining them in nets placed on the trees, was unable to discover oviposition and it is not yet satisfactorily shown that the complete life cycle of the species has been discovered. Osten Sacken (1865, p. 341), greatly impressed with Walsh's work, predicted that perhaps "in some cases, the galls producing the dimorphous females were somewhat, or perhaps even altogether, different from those producing the bisexual brood," thus anticipating a summary of the rule which was not to be proved satisfactorily for another twenty years.

European zoologists had long been impressed by Hartig's observation (1840) that among almost 10,000 females bred from one species of gall not a single male was discovered. Similar experience had been had by all the students of gall-wasps and Giraud is quoted (Lichtenstein, 1881, p. xi) as remarking "Il a y dans ces Cynipides agames un mystère dont la découverte fera la gloire d'un homme." To solve this mystery, Dr. Hermann Adler, a physician at Schleswig, undertook to raise under controlled conditions successive generations of species of cynipids. In 1877 he made the first report of his work and, when he made the more complete report, in 1881, the abundance of his observations with a number

¹Riley's share in the discovery consisted, according to his own early statement (1873), in this breeding of the adult from one form of gall—nothing more. That this adult or the gall from which it came had any connection whatsoever with the other form of gall was realized only because of Bassett's observations made 1864 to 1873. Overlooking this situation, Lichtenstein (1881) and Howard (1882 and 1910), followed by later reviewers, gave Riley the whole credit and by 1895 Riley himself had come to believe he deserved it. He then writes: "The writer established, by breeding, the connection of the agamic *Callirhytis operator* O. S. and *C. operatola* Riley in 1872, the facts and specimens having been communicated to H. F. Bassett July 10th of that year, though not published till 1873." But *C. operator* is not agamic, *C. operatola* is not a Riley species (it was published by Bassett in 1900), and the dates in this statement are at utter variance with Riley's published statement of 1873, where he expressly gives the date of breeding the acorn gall-wasp as 1873. I possess the copy of the French translation of Adler's work presented by Lichtenstein to Riley. Among several notes made in Riley's own handwriting is this: "Wrote to Bassett May 7/72 in reference to black flies from *C. g. operatola* & again July 10/73 announcing breeding of large ♀ from it." Fifteen years later Riley's black flies (inquilines or parasites) of May 7, 1872, had become in his mind the large female (true gall maker) of July 10, 1873.

of different species showed alternation of generations in Cynipidæ to be a fact not to be questioned and presented the proof in a way which immediately attracted attention from biologists over the world. What Bassett and Walsh had proven for three American species was now proved for fourteen European species by direct observation of the complete life cycle and for five other species where the second form of the gall was obtained from the first, but the return experiments were not successful. Other facts of importance concerning the life histories of other species were reported at the same time. None of the later workers have equaled that number of life histories solved, nor can any amount of later work ever prove as important as was the convincing work done by Adler.

The life histories of other European species have been solved by Beyerinck, Schlechtendal, Kieffer, and others. In America, Bassett solved the life histories of four species, Walsh and Triggerson of one each, and now I can add information concerning three other species. This, including two cosmopolitan species which Adler studied, totals ten or eleven American species of which the life cycles have been determined.

LIFE HISTORIES

Aylax glechomæ (Linnæus)

Plate XXVIII, Figures 1 and 2

The following includes only the most important of the many references in European literature, with a more complete bibliography of American literature.

[No name] PANKOW, 1656, Herbar. Portat., p. 709.

Cynips glechomæ LINNÆUS, 1758, Syst. Nat., 10th Ed., p. 553.

Diplolepis glechomæ LATREILLE, 1805, Hist. Nat. Crust. & Ins., XIII, p. 207.

Aylax glechomæ HARTIG, 1841, Zeitschr. f. Ent., III, p. 342. BEUTENMÜLLER, 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 138, Pl. xiv, figs. 1-3. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 667, figs. 347-348. FELT, 1918, N. Y. State Mus. Bull., CC, p. 183, figs. 198, 235 (1-3).

Aulax glechomæ HARTIG, 1843, Zeitschr. f. Ent., IV, p. 412. DALLA TORRE, 1893, Cat. Hymen., II, p. 120. JOHANNSEN, 1911, Me. Agric. Exp. Sta. Bull., CLXXX-VII, p. 8. FAGAN, 1918, Amer. Nat., LII, p. 168.

Diastrophus glechomæ SCHENCK, 1862-1863, Jahrb. v. Natur. Nassau, XVII-XVIII, pp. 211, 212, 248. ADLER, 1881, Alternating Generations (Straton Edit.), p. 274.

Aulax glechomatis MARSHALL, 1868, Ent. Month. Mag., IV, p. 274.

Liposthenes glechomæ FÖRSTER, 1869, Verh. zool.-bot. Gesell. Wien, XIX, p. 336. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 25, 44.

Liposthenes glechomatis MARSHALL, 1874, Ent. Ann., p. 117.

Diastrophus similis BASSETT, 1881, Can. Ent., XIII, p. 95. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 294, 304; 1887, idem, XIV, p. 134. DALLA TORRE, 1893, Cat. Hymen., II, p. 109. MAYR, 1902, Verh. zool.-bot. Gesell. Wien, LII, p. 287. COOK, 1903, Ohio Nat., III, p. 428, figs. 66-69; 1904, idem, IV, pp. 119, 120, 126, figs. 86, 106. VIERECK, 1916, Hymen. Conn., p. 436.

Aulax similis DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 75.

Diastrophus siminis COOK, 1904, Ohio Nat., IV, p. 135.

Aulax (Diastrophus) similis SMITH, 1910, Ins. N. J., p. 603.

FEMALE.—Mostly piceous black; pronotum dark rufous anteriorly, with patches of long, yellowish hairs at the sides; second abdominal segment produced dorsally to almost two-thirds the length of the abdomen; areolet small or lacking. **HEAD:** piceous black or black, reddish on the face, mouth-parts yellowish rufous; slightly broadened behind the eyes; a broad, median facial elevation; microscopically rugose, more rugose on the face, striate, somewhat radiantly around the mouth; somewhat hairy; antennæ yellowish or light brownish rufous, 13-jointed, finely pubescent. **THORAX:** almost entirely black, mesonotum superficially appearing smooth and shining, but actually finely coriaceous or shagreened; parapsidal grooves distinct, continuous to the pronotum where they are divergent; anterior parallel lines rather faint, half the length of the mesonotum; median groove absent or barely indicated by a slight rugosity at the scutellum; lateral lines distinct but not deep, extending half the length of the mesonotum; scutellum very rugose, with two, rather large, round, mostly smooth and shining foveæ at the base separated by a rather fine ridge; pronotum black or piceous laterally, dark rufous anteriorly, rugose, hairy, with patches of long, yellowish hairs at the sides; mesopleuræ piceous or black, shining, rugoso-striate. **ABDOMEN:** rufo-piceous to black, mostly smooth and shining, with patches of dense, yellowish hairs at the base, laterally; the second segment produced dorsally, extending dorsally almost two-thirds of the length of the abdomen. **LEGS:** entirely yellowish or light brownish rufous, finely hairy; the tarsal claws darker in color, and simple. **WINGS:** yellowish-tinged, the veins yellowish brown, darkest on the basal half of the wing; areolet small or lacking, radial cell entirely open; the cubitus fine and very faint where it meets the basal vein considerably below the midpoint; the first abscissa of the radius entirely arcuate or sometimes subangulate. **LENGTH:** 2.5–3.2 mm.

GALLS.—Rounded galls (Figs. 1 and 2) on the leaves, petioles, or stems of *Nepeta (Glechoma) hederacea*, the ground-ivy (gill-over-the-ground). Monothalamous, or several galls fused. Each gall is 6–12 mm., more or less, in diameter, rounded, covered with a rather dense, stiff pubescence, reddish and green when young; when old becoming dry, brown, smooth, with a thin, papery covering separating more or less or entirely lost from the gall during the winter. The larval cell is central, held in place by rather abundant, very irregular, coarse fibers.

TYPES.—Types of *glechomæ* in the Linnæan collections and most likely lost. Cotypes of *similis* in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

RANGE.—Europe. Maine: Orono (Johannsen). Massachusetts: Boston (Clarke); Sharon. Connecticut: Waterbury (Bassett). New York: Long Island (Bassett). New Jersey: Alpine (Beutenmüller). Ohio (Cook). Indiana (Cook). Illinois (Beutenmüller.)

Mayr first pointed out the synonymy of the European *glechomæ* and Bassett's *similis*. I made the above redescriptions from European material from Mayr and also from Bassett's types, and the identity of the two is quite certain. The species was undoubtedly introduced into America from Europe, for its host, the ground-ivy, is of European origin. It is likely that galls were brought to America on plants which had be-

come entangled in nursery material or used as packing. It is very interesting to find insects of so little vitality living through such a journey, and upon emergence from the galls to be able to endure the new conditions and to find the hosts necessary for the continuance of the species. There are only three other instances of the sort. The introduction of *Rhodites rosæ* and *R. mayri*, of roses, is easily understood, but the successful introduction of *Aylax glechomæ* and of *A. taraxaci* (not yet recorded from Europe, but since the dandelion is of European origin it is probable that the gall-wasp is also introduced) upon herbaceous plants is more surprising.

This species is, in many respects, very distinct from and more specialized than other members of the genus *Aylax*. The striations of the face resemble those of *Diastrophus*, the second abdominal segment is remarkably developed, the monothalamous and separable gall is (as I am showing elsewhere) a good indicator of advanced evolution, and the undoubtedly completely agamic reproduction is not found elsewhere, as far as is known, in the genus. These and other considerations suggest that *glechomæ* must be considered a high development in *Aylax* or possibly as belonging to a distinct genus.

The galls appear in late May or early June. In this young condition they are eaten in France. The galls mature in late July and, as the plants begin dying off in September, the dried galls drop to the ground where they overwinter, being in large part decayed by springtime. The galls are heavily parasitized. The insects mature in the fall and overwinter as adults, not emerging, however, until the following April or May. Adler proved, by experimentally raising successive generations, that there is no alternation of generations with the species and, since the male is unknown, it is likely that reproduction is regularly agamic, the eggs never being fertilized. This pure agamy is a remarkable condition not easily comprehended as a fit method of maintaining the vitality of an organism.

***Rhodites rosæ* (Linnæus)**

Plate XXVIII, Figures 3 and 4

[No name] MALPIGHI, 1679, Anat. Plant., II, pp. 28, 41.

Cynips rosæ LINNÆUS, 1758, Syst. Nat., 10th Ed., p. 553.

Diplolepis bedeguaris GEOFFREY, 1762, Hist. Ins., II, p. 310.

Diplolepis rosæ FOURCROY, 1785, Ent. Paris, p. 392.

Diplolepis bedeguaris fungosæ LAMARCK, 1817, Hist. Anim., IV, p. 163.

Rhodites rosæ HARTIG, 1840, Zeit. Ent. Germ., II, p. 194. FÖRSTER, 1869, Verh. zool.-

bot. Ges. Wien, p. 332 [*rosæ* fixed as type of *Rhodites*]. ADLER, 1877, Deut. Ent. Zeit., XXI, p. 209 [Biology]. PASZLAWSZKY, 1882, Természettajzi Füzetek [Budapest], V, pp. 192, 277 [Biology]. And many other references in European literature.

Detailed descriptions or illustrations are to be found in the following more available American publications:

COMSTOCK, 1895, Man. Study Ins., p. 621, fig. 747. BEUTENMÜLLER, 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 7, fig.; 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 632, figs. 1-4, Pl. XLIII, figs. 5-6. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 22, 45, Pl. v, fig. 92. VIERECK, 1916, Hymen. Conn., p. 441, Pl. VI, fig. 5. LUTZ, 1918, Field Book Ins., p. 468, Pl. C, fig. 5. FELT, 1918, N. Y. State Mus. Bull., CC, p. 144, fig. 149, Nos. 5-6.

FEMALE.—Head, antennæ and thorax entirely black; abdomen red, piceous black posteriorly; wings with a large brown cloud covering the radial cell and extending beyond it. **HEAD:** entirely black or piceous black, mouth-parts reddish brown, tips of the mandibles black; front finely coriaceous, face rugoso-punctate with scattered hairs; antennæ entirely black, pubescent, 14-jointed, the third joint about twice as long as the fourth. **THORAX:** entirely black, mesonotum coriaceous; anterior parallel lines and lateral lines smooth; parapsidal grooves and median groove more apparent in some specimens than in others; parapsidal grooves sometimes traceable to the pronotum; scutellum black, finely rugose, the foveæ at the base similarly rugose and hardly distinct from the rest of the scutellum; pronotum rugose; mesopleuræ almost wholly smooth and shining, with a narrow, rugose area dividing the shining area unequally. **ABDOMEN:** bright red, lightest basally, the posterior segments piceous black, the hypopygium reddish brown and with a few, short hairs, abdomen otherwise smooth; second segment produced dorsally, there equalling almost two-thirds the total length of the abdomen; the hypopygium prominent, broad, acutely-pointed, "plow-shaped." **LEGS:** coxæ rufo-piceous to light reddish brown, tibiæ and tarsi light reddish brown; legs entirely hairy; tarsal claws simple. **WINGS:** yellowish-tinged, a large brownish area entirely covering the radial cell and extending considerably beyond it; wing-veins clear brown, darkest on the first abscissa of the radius; areolet moderately large; cubitus extending to the basal vein; radial cell entirely closed, first abscissa of the radius arcuate on the inner side, but with a considerable thickening on the other side, which makes it angulate into the radial cell. **LENGTH:** 2.7-3.5 mm.

MALE.—Similar to the female, differing as follows: third antennal joint almost three times as long as the fourth; abdomen small, black, piceous or reddish basally; wings without the radial cloud; length, 2.0-2.5 mm.

[The above descriptions made from large series of specimens from localities over Massachusetts.]

GALLS.—A large mass (Figs. 3 and 4) of moss-like filaments surrounding a cluster of hard, bud-like cells. The filaments are pale green or reddish or purplish-tinged when young, becoming brown or black during the winter; they are sometimes simple, forming a tangled mass, or may be broad, branched, or leaf-like; the whole gall is spherical or oval, about 50 mm. or less in diameter. Each cell of the central core is a modified bud, monothalamous, thick-walled, with a distinct but inseparable larval cell; the cell is more or less covered with irregular projections; and often several cells fuse. Terminal on the stems of roses, especially of the sweet briar; it has been recorded from eighteen species of rose, and is likely to be found on almost any of the species.

TYPES.—In the Linnæan collections and most likely lost.

RANGE.—Europe: throughout. Asia: western. North America: Canada (Toronto, Quebec) and New England to Georgia, west to Michigan, Kansas, and Colorado.

The gall of this species is one of the best known of the cynipid productions, being large and attractive and occurring most often on cultivated plants or on bushes escaped from cultivation. The species is evidently of European origin, probably having been imported into North America and other parts of the world on the sweet-briar. This is one of the four known instances of the importation of a cynipid species from one continent into another.

The gall is a curious modification of the young leaves. It is among the most specialized of the *Rhodites* galls. But what has been gained by the specialization is not altogether apparent, for the amount of parasitism of this species is great (at least 15%), and evidently the peculiar devices which complicate the gall are of no avail in keeping out parasitic insects.

The galls of *rosæ* appear as early as June 5 (Adler, 1877), about three weeks after the eggs are laid; these galls are well grown in late July and mature by September. The insects overwinter as larvæ and pupate only a few days before their emergence from the gall. The adults emerge from April 27 to July 9. This is a wider range of dates of emergence than is commonly found among the Cynipidæ and, unlike practically all of the other gall-wasps, adults of this species will sometimes emerge from a single gall at two or more dates separated by a month or more, indicating a considerable range of differences between the eggs from a single parent. The adults oviposit within a few hours after emergence, but may live for four or five days before dying.

Males and females are sometimes produced in about equal abundance. From my first lot of material I bred six females and seven males, and Cameron reported (1889) a similar experience. But other galls will give no males at all, indicating a great variation in the eggs laid by different individuals. The final average gives between one and two per cent males, and the observations of several workers (Adler, 1888; Cameron, 1889; *et al.*) confirm my experience in this respect. It is to be expected that under such conditions the females are often not fecundated but, nevertheless, the eggs of such individuals will grow parthenogenetically. This was very positively proved by Adler (1877), who secured galls from eggs he had observed to be laid in the plant. He conducted extensive experiments with this species; in four different years he obtained similar results, rearing three generations in direct succession, obtaining galls

and adults in each case exactly like those of the parent generation. This was conclusive proof that there is no alternation of generations with this species, and nothing known of its life history would suggest that an alternation ever occurs. By strictly isolating the females from the males at emergence and before oviposition, and by anatomical examination of the receptaculum, Adler proved the parthenogenetic development of eggs.

***Rhodites ignotus* Osten Sacken**

Plate XXVIII, Figures 5 to 7

Rhodites ignota OSTEN SACKEN, 1863, Proc. Ent. Soc. Phila., II, pp. 44, 45, 49. GILLETTE, 1892, Ent. News, III, p. 246. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 246, Pl. IX, fig. 2; 1904, Amer. Mus. Journ., IV, p. 94, fig. 7; 1904, idem, XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 8, fig. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 621, 647. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 37, fig. 73. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 23, 45, Pl. v, fig. 100. LUTZ, 1918, Field Book Ins., p. 468, Pl. c, fig. 8. [*R. ignota* of Ashmead papers is *R. globuloides* Beutenmüller.]

Rhodites carolina ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, pp. 133, 148. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 78. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 718. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 23, 45.

Rhodites carolinus DALLA TORRE, 1893, Cat. Hymen., II, p. 126.

Rhodites ignotus DALLA TORRE, 1893, Cat. Hymen., II, p. 127. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 78. BEUTENMÜLLER, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 634, Pl. XLIII, figs. 7-10. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 718, fig. 402. SMITH, 1910, Ins. N. J., p. 604. COSENS, 1912, Trans. Can. Inst., IX, p. 350. VIERECK, 1916, Hymen. Conn., p. 441, Pl. VI, fig. 3. FELT, 1918, N. Y. State Mus. Bull., CC, p. 146, fig. 149 (7-10).

FEMALE.—Antennæ, head, and thorax black; basal joints of antennæ rufous; abdomen and legs rufous red; radial area of wings clouded but with a large clear spot in the center. HEAD: broad; black or piceous black, shallowly rugoso-punctate, more finely punctate on the vertex, with a long pubescence on the face; antennæ short, 14-jointed, black or piceous black, joints one and two light rufous to rufo-piceous. THORAX: black, coarsely rugose, hairy; parapsidal grooves similarly rugose, widely divergent from the scutellum, extending a little more than half the way to the pronotum; median groove lost in the rugosities of the mesonotum; anterior parallel lines fine, smooth, slightly raised, not extending half-way to the scutellum; lateral lines broader, smooth, about as long as the parapsidal grooves; scutellum long, elevated, depressed at the base but without distinct foveæ, entirely coarsely rugose; mesopleuræ rather smooth and shining, in part coriaceous, a narrow rugose band extending across the middle. ABDOMEN: bright rufous red, the tip of the hypopygium rufo-piceous; smooth and shining, the lower edge of the hypopygium hairy; abdomen long and slender; the second segment produced dorsally almost to the tip of the abdomen; hypopygium "plow-shaped." LEGS: bright rufo-piceous including the coxæ, the last joints of the tarsi rufo-piceous; densely hairy; tarsal claws simple. WINGS:

yellowish-tinged, hairy, the veins clear brown, those bounding the radial area darker; radial area closed, covered with a large, brown patch with a large, clear spot in the center; areolet moderately large, cubitus not quite reaching the basal vein below its midpoint; first abscissa of the radius distinctly angulate but without a distinct projection into the radial area. LENGTH: 2.0–3.5 mm.

MALE.—Similar to female but differing as follows: basal joints of antennæ piceous brown; abdomen piceous, shorter, more compressed, and more slender basally; wings with only traces of the clouds on the radial areas, with a slight projection from the first abscissa of the radius into the radial cell; length, 1.5–3.0 mm.

[Redescription made from New England and New York material compared with cotypes.]

GALLS.—Irregularly globose leaf-galls (Figs. 5 to 7), covered with a white, mealy powder. Each gall is about globose, monothalamous, but often several galls coalesce to form large, elongate, more or less entire masses sometimes 20 mm. long. On the terminal twigs, petioles, and stems of the leaflets of *Rosa blanda*, *R. carolina*, *R. humilis*, *R. nitida*, *R. virginiana*, and most likely other roses.

COTYPES.—Cotype females and galls in the Museum of Comparative Zoology, and "cotype" galls in The American Museum of Natural History.

RANGE.—Ontario: Toronto (Cosens). Massachusetts: Magnolia, Boston (Clarke); Westboro (Frost); Springfield (Stebbins). Rhode Island: Providence (Thompson). Connecticut: New Haven, Woodbridge (Britton); Waterbury (Bassett). New York: Albany (Felt); Nyack (Zabriskie); New York City (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Fort Lee (Beutenmüller); Patterson, Bradley Beach (in Coll. Amer. Mus.). Pennsylvania (Beutenmüller). Maryland: Fareman (Osten Sacken). District of Columbia: Washington (Beutenmüller). North Carolina: Black Mts. (Beutenmüller); Asheville (Ashmead). Florida (Ashmead). Iowa (Beutenmüller). Colorado: Fort Collins (Gillette).

The galls of *Rhodites ignotus* are first noticeable about the middle of August, somewhat deforming the leaves of the roses on which they are formed. The galls overwinter, sometimes on the bush, but often on the ground, to which they readily fall when the leaves bearing them wither in the autumn. The mature wasps are known to emerge the following spring from May to August, most of the adults appearing about the last of May or the first of June. As with *R. rosæ*, this extended period of emergence is an unusual thing to find among the gall-wasps. Of thirty-seven of the wasps which I have bred, thirteen, i. e., 35% of them were males, which is a higher percentage than that known from other species of the genus. However, incomplete observations on other breedings I have made would indicate a much lower percentage of males to be more nearly normal. The number of parasites obtained from these galls is extremely high; I have found them to constitute about 90% of all the insects bred—another instance of the inefficacy of highly developed "protective" devices. Most of these parasites are figitids, Synerginae, etc., the so-called "inquilines," but many other parasitic Hymenoptera also attack the galls.

The adults of *ignotus* live for only a few days at the most, oviposition often occurring only a few hours after emergence. The females will refuse to oviposit unless they find a bush in the right condition for receiving the eggs. A lot of the insects which I placed on a cultivated rose which was somewhat retarded in development refused to climb over the bush at all to examine the buds, though the same insects became active enough when placed on a plant in a more advanced state of development. They carefully examined the young leaves, hardly yet out of the buds, and in these leaves the eggs were laid. The quantities of parasites which emerged, mostly a couple of weeks after the cynipids, were very active in examining the leaves of the same plant and many of them were observed to oviposit, but whether into the eggs and very young galls of the gall-wasps I am not certain.

The points at which oviposition was made by the *ignotus* females were carefully marked and kept covered by gauze bags for almost a month and a half. The galls produced were first seen about the first of September, i. e., over a month and a half after the eggs were laid, but the degree of development of the galls indicated that they had appeared possibly two weeks earlier. The galls thus obtained were typical *ignotus* galls, in every way resembling the galls of the parent generation. Nothing else known of the life history of the species would suggest that it possesses an alternation of generations. Ants attacked the cynipids when they died after oviposition and only a single whole specimen, a male, was rescued for the collection. This, with galls of the two successive generations, are in my collections, distinctively labelled. I cannot say positively whether the reproduction is wholly or at any time parthenogenetic, though it is very likely that it is parthenogenetic at least part of the time. The one male in my net may have fertilized the females, though I did not observe copulation.

***Neuroterus batatus* (Fitch)**

In most of the following references the two generations have not been separately described.

Cynips Quercus-batatus FITCH, 1859, Report Nox. Ins. N. Y., p. 810.

Cynips quercus batatus OSTEN SACKEN, 1861, Proc. Ent. Soc. Phila., I, p. 71. THOMES, 1879, Trans. Ill. Hort. Soc. for 1878, p. 198. PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 39; 1890, 5th Report U. S. Ent. Comm., p. 111.

Cynips q.-batatus OSTEN SACKEN, 1861, Ent. Zeit. Stett., XXII, pp. 410, 414. BASSETT, 1864, Proc. Ent. Soc. Phila., III, p. 684; 1877, Can. Ent., IX, p. 121. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 113.

Cynips batatus OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, pp. 340, 344, 350, 354. PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.

Neuroterus batata MAYR, 1881, Gen. Gallenbew. Cynip., p. 37. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 296. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 107.

Neuroterus batatus BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 132; 1890, Colo. Biol. Assoc. Bull., I, p. 38. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 262, Pl. XIII, fig. 1; 1904, Amer. Mus. Journ., IV, p. 107, fig. 41; 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 26; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 21, fig.; 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 117, Pl. VIII, figs. 1-8. DALLA TORRE, 1893, Cat. Hymen., II, p. 40. BRODIE, 1896, Ann. Report Forest. Ont., p. 117, fig. 3. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 50. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 618, 624; 1918, N. Y. State Mus. Bull., CC, pp. 56, 58, fig. 54. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 29. SMITH, 1910, Ins. N. J., p. 598. COOK, 1910, Mich. Geol. and Biol. Surv. Publ. 1, p. 31. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 6, 40, Pl. I, fig. 76. VIERECK, 1916, Hymen. Conn., p. 384. LUTZ, 1918, Field Book Ins., p. 464, Pl. xcvi, fig. 4.

Neuroterus quercus-batatus DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 334, fig. 55.

[*Neuroterus batatus* FULLAWAY, 1911 = *N. pacificus* Beutenmüller.]

RANGE.—Canada (Brodie). New Hampshire: Wolfeboro. Massachusetts: Auburn, Boston, Blue Hills, Marthas Vineyard. Rhode Island: Providence (Thompson). Connecticut: New Haven (Champlain, Walden); Waterbury (Bassett). New York: Neperan, Long Island, Staten Island (Beutenmüller). New Jersey: throughout (Smith). Virginia (Riley). Ohio (Beutenmüller). Illinois (Beutenmüller). Michigan (Cook). Colorado (Ashmead).

***Neuroterus batatus* form *bisexualis*, new name**

Plate XXIX, Figures 8 and 9

FEMALE.—Almost entirely black except the legs and antennæ which are yellowish and brown; areolet large; length about 2.0 mm. HEAD: black; mouth-parts reddish; shagreened; sparsely hairy; antennæ 13-jointed, first three joints yellowish, the remaining joints brownish; hairy. THORAX: piceous black, shining, very finely shagreened, shrivelling on drying; parapsidal grooves, anterior parallel lines, etc., not present or sometimes very faintly traceable; scutellum black, broadly oval, finely shagreened, sparsely hairy; a distinct, arcuate depression separates the scutellum from the thorax; pronotum and mesopleuræ reddish piceous. ABDOMEN: reddish piceous to black, smooth, shining, shrivelling on drying, angular in outline, as deep as long, the second segment extending not much more than one-third the total length. LEGS: dark brown, hairy, yellowish at the joints, and on all the tarsi and on the tibiæ of the first and second pairs of legs. WINGS: large, much longer than the body, clear; veins clear brown; areolet large; cubitus reaches the basal vein; radial area completely open on the margin; first abscissa of the radius angulate, the angle little more than a right angle but the apex high upon the vein. LENGTH: 1.2-2.0 mm.

MALE.—Differs from the female as follows: head, thorax, and abdomen reddish to light piceous, the antennæ and legs entirely yellow; antennæ 14-jointed, the third joint curved; abdomen petiolate; wings yellowish, the veins yellowish brown, areolet of moderate size; length, 1.2-2.0 mm.

[Redescribed from New England specimens compared with Bassett's morphotypes.]

GALLS.—Moderate-sized swellings (Figs. 8 and 9) of young stems and petioles, essentially the same as the galls of the agamic generation (q. v.), but differing in being often much smaller, often having tufts of short, woolly pubescence. On stems, petioles, or midveins of *Quercus alba*.

TYPES.—Bassett's morphotype females, males, and galls in the collections of The American Museum of Natural History, of the Academy of Natural Sciences of Philadelphia, and of the Museum of Comparative Zoology.

In 1864 Bassett reported that he had observed for a number of years the alternation of two crops of galls on a small tree near his house. The abundance of each crop in turn suggested the relationships of the two. Moreover, the insects proved indistinguishable except through a slight difference in size and in the then unexpected condition of having only females in the winter galls, with both males and females in about equal numbers from the spring galls. Neither Bassett nor later workers have actually seen the oviposition of the species, nor obtained under controlled conditions the gall of one generation from an egg deposited by a female of the previous generation, but Bassett's field experience is regularly confirmed by later collectors of gall-wasps. I have examined material from the Bassett collection which shows this, also photographs of material collected by Miss Cora Clarke, and a quantity of material collected and bred by Millett T. Thompson. This latter material shows the two generations often close together on successive parts of the same branch. The descriptions here given are made from a study of many specimens which I have compared with the Bassett types. No previous separation has been made of descriptions of the two forms of adults, and the gall of the bisexual generation has never been described in detail, nor have Latin names been applied to distinguish the forms.

The galls of the bisexual generations appear about the middle of May and the adults emerge, in about equal numbers of the sexes, by the middle of June. These oviposit in the new wood of the stem on which the better-known gall of the agamic generation develops.

***Neuroterus batatus* form *batatus* (Fitch)**

Plate XXIX, Figures 10 to 13

FEMALE.—Almost identical with the female of the bisexual generation, but with the thorax usually less wrinkled and, in consequence, the anterior parallel lines more evident. The insect averages slightly larger than the female of the other generation, the abdomen being somewhat less angulate in outline. **LENGTH:** 1.7–2.2 mm.

GALLS.—Large, woody, stem swellings (Figs. 10 to 12). Polythalamous. Averaging 40×10 mm., often larger; tuber-like, irregular, but usually roughly cylindrical, elongate, involving stems and bases of petioles on terminal twigs; inseparable

from the rest of the plant. Bark-colored, reddish, purplish brown, or with a glaucous bloom. Internally the galls are solid, woody, the larval cells scattered irregularly, the cell walls hardly distinct and not at all separable from the surrounding tissues. On terminal stems of *Quercus alba* (not known definitely from any other species of oak).

TYPES.—Bassett morphotype females and galls in the collections of The American Museum of Natural History, the Museum of Comparative Zoology, and of the Academy of Natural Sciences of Philadelphia, and Fitch cotype galls in the Museum of Comparative Zoology.

The galls of this generation, because they remain upon the tree for the longer time and often reach the larger size, are the better-known of the two forms of this species. The insects live in the galls over winter, emerging late the following April or early in May.

The very great similarity of the adults of the two generations of this species (except for the agamy in the winter generation) and the essentially identical plan of the galls of the two forms, is a matter of great interest. In this species, as in *Neuroterus noxiosus*, we find as simple a case of alternation of generations as has yet been recognized. The differences in the galls are very evidently due to seasonal differences of the conditions in the part of the host affected.

***Neuroterus noxiosus* (Bassett)**

In most of the following references both generations, at least of the gall, are described separately.

[No name] BASSETT, 1873, Can. Ent., V, p. 92; Trans. Ent. Soc. Lond., p. xv.

Cynips noxiosa BASSETT, 1881, Can. Ent., XIII, p. 108. PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 57.

Neuroterus noxiosus MAYR, 1881, Gen. Gallenbew. Cynip., p. 37. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 296, 303. GILLETTE, 1888, 27th Report Agric. Mich., p. 471; 1889, Psyche, V, p. 187. PACKARD, 1890, 5th Report, U. S. Ent. Comm., pp. 107, 109. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 262; 1904, Amer. Mus. Journ., IV, p. 107, fig. 42; 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 21, fig.; 1910, Bull. Amer. Mus. Nat. Hist., XXVIII, p. 118, Pl. IX. DALLA TORRE, 1893, Cat. Hymen., II, p. 44. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 51; 1910, Das Tierreich, XXIV, p. 330. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 618, 624, 711; 1918, N. Y. State Mus. Bull., CC, pp. 58, 84, fig. 55. NASON, 1906, Ent. News, XVII, p. 8. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 30. SMITH, 1910, Ins. N. J., p. 598. COOK, 1910, Mich. Geol. & Biol. Surv. Publ. 1, p. 30. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 6, 13, 41, Pl. IV, fig. 118 [not Pl. I, fig. 16]. VIERECK, 1916, Hymen. Conn., p. 391. LUTZ, 1918, Field Book Ins., p. 464, Pl. xcvi, fig. 11.

Neuroterus noxiosa ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 132.

RANGE.—Massachusetts: Everett (Clarke); Boston; Amherst (Thompson); Springfield (Stebbins); Marthas Vineyard. Rhode Island: Providence (Thompson).

Connecticut: New Haven (Champlain, Walden); Waterbury (Bassett). New York: New York City (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Fort Lee (Beutenmüller); New Brunswick (J. B. Smith). Illinois: Algonquin (Nason). Iowa (Beutenmüller). Michigan: Lansing (Gillette).

***Neuroterus noxiosus* form *vernalis*, new name**

Plate XXIX, Figures 14 to 16

FEMALE.—Head, thorax, and abdomen mostly black; antennæ yellowish, shading into brown toward the tip; areolet rather small; length about 1.5 mm. **HEAD:** black, shading into rufous brown on the lower half of the face and on the mouth-parts; finely coriaceous to punctate; antennæ 13-(14-)jointed, yellowish, shading into brownish toward the tips. **THORAX:** black, or piceous black, finely coriaceous; without more than very faint traces of anterior parallel lines, parapsidal grooves, etc.; scutellum black, finely coriaceous, separated from the mesonotum by a deep, distinct, arcuate groove. **ABDOMEN:** black or piceous, smooth and shining, shrivelling on drying, angulate in outline; the second segment about only one-third as long as the whole of the abdomen. **LEGS:** light golden yellowish, the middles of the femora, the hind coxæ and tibiæ, and the tips of the tarsi dark brown; hairy. **WINGS:** long, clear, the veins light brown in color, areolet moderately small; cubitus reaching the midpoint of the basal vein; radial cell long and narrow, open (rarely in small part closed on the margin); the first abscissa of the radius angulate, the apex of the angle above the middle of the vein and without a very distinct projection into the radial cell. **LENGTH:** 1.2–1.7 mm.

MALE.—Similar to the female, but with legs and antennæ entirely yellowish; antennæ 14-jointed, the third joint curved; the first abscissa of the radius showing a slight projection into the radial cell; abdomen small, petiolate; length, 1.0–1.4 mm.

[Redescription made from a large amount of New England material which was compared with the types.]

GALLS.—Irregular clusters of woody swellings (Figs. 14 to 16) of the stems, petioles, and leaves. Polythalamous. The whole mass roughly about 20×40 mm. in diameter or less, inseparable from the plant; fist-like, the separate parts woody, indicating the separate leaves or parts of leaves involved, and bearing a small portion of deformed leaves; these parts are united by the deformed petiole, or by a fused mass of petioles or young twigs. The gall is bark-colored, or tinged with a glaucous bloom. Internally the larval cells are crowded closely together, the cells very distinct but not separable from the surrounding woody tissue. On the young growth of *Quercus* *Prinus* and *Q. bicolor*.

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

When Bassett first described this species he gave detailed descriptions of the galls of the two generations and noted differences in sizes of the adults. The specific relations of the two generations had been arrived at through the field observation of the alternate abundance of the two forms of galls and the close similarity of the adults of the successive generations. The tremendous abundance of this species locally often gives abundance opportunity for observations. Gillette, Beutenmüller,

Miss Clarke, Thompson, and other students of the family have made observations confirming Bassett's statements, and there can be no doubt of the regular alternation of these forms, even though the data has not been checked by experimental work. This was the fourth and last instance of heterogeny discovered by Bassett.

The galls of this form appear when the young leaves first unfold in May and, like most of the spring galls of dimorphic species, grow very rapidly to maturity. The adults are known to emerge from June 12 to July 5. They occur in about equal numbers of the sexes: I counted 276 females and 233 males in one lot bred by Millett T. Thompson. After fertilization the females oviposit in the new wood of the twigs, usually not far from the galls in which they have developed.

***Neuroterus noxiosus* form *noxiosus* (Bassett)**

Plate XXIX, Figures 17 to 19

FEMALE.—Almost identical with the female *vernalis*, with the thorax and abdomen more piceous, especially at the base of the abdomen; the anterior parallel lines on the mesonotum more distinct, the abdomen relatively larger and more angulate; the wing veins slightly darker brown; the whole length 1.6–2.0 mm.

GALLS.—Irregular, elongate, woody swellings (Figs. 17 to 19) of young stems and sometimes petioles. Polythalamous. About 60×10 mm., roughly cylindrical, but often very irregularly twisted, etc. Inseparable from the plant. Bark-colored, usually with a glaucous bloom. Internally the gall is closely packed with larval cells which are distinct but not separable from the surrounding woody tissue. On the newer growth of *Quercus bicolor*, *Q. Prinus*, and possibly other oaks.

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

This gall is the better-known form of the species, due apparently to its longer persistence on the tree. The gall very closely resembles that of *Neuroterus batatus batatus*, from specimens of which it is often difficult to distinguish this species. The more highly distinct larval cells of *noxiosus* is often a good basis for making the distinction. The most certain test, however, is the species of the host plant, *noxiosus* being confined as far as known to *Quercus bicolor* and *Q. Prinus*, while *batatus* occurs on *Q. alba*. It would prove interesting to try to induce one of these species to oviposit on the "wrong" species of oak, and to observe if galls and what galls were produced.

The larvæ of *noxiosus* overwinter in the galls, emerging the following spring from March 24 through April to early May.

***Neuroterus tectus* Bassett**

Neuroterus tectus BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 331. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 51; 1910, Das Tier-

reich, XXIV, p. 337. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 26; 1910, idem, XXVIII, p. 126, Pl. XII, figs. 1-2. SMITH, 1910, Ins. N. J., p. 599. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 5, 13, 41. VIERECK, 1916, Hymen. Conn., p. 389. FELT, 1918, N. Y. State Mus. Bull., CC, p. 56, fig. 53, 1-2.

RANGE.—Massachusetts (Thompson). Rhode Island: Providence (Thompson). Connecticut (Bassett). New York (Beutenmüller). New Jersey (Beutenmüller). Pennsylvania (Beutenmüller).

***Neuroterus tectus* form *tectus* (Bassett)**

Plate XXX, Figures 20 to 22

FEMALE.—Mostly piceous black, antennæ 13-jointed, wing-veins brownish, areolet only moderately large; length about 1.2 mm. HEAD: piceous or piceous black, mouth-parts reddish brown, microscopically coriaceous; a distinct median elevation on the face; antennæ 13-jointed, dark brown, lighter basally. THORAX: piceous or piceous black, shining; mesonotum almost entirely smooth, the parapsidal and other grooves lacking, scutellum rounded, the groove at the base broad and deeply arcuate; pronotum and mesopleuræ very microscopically coriaceous. ABDOMEN: Blackish, piceous basally, shining, triangular in outline. LEGS: brownish, straw-brown at the joints. WINGS: narrow, one-third again as long as the whole body; veins straw-brown, distinct but not heavy; areolet moderately large or not large; cubitus continuous to the basal vein which it meets slightly below the mid-point; radial area long and narrow, open, the first abscissa of the radius somewhat angulate high on the vein. LENGTH: 1.2-1.5 mm.

MALE.—Similar to the female, but with the antennæ lighter colored, the third joint slightly curved, the abdomen petiolate.

[Redescribed from Thompson material bred in successive generations, and from Bassett cotypes.]

GALLS.—Small swellings (Figs. 20 to 22) of the stems of flower clusters, of petioles, or of young stems of oak. Each swelling consists of closely-packed clusters of thin-walled, oval larval cells, each measuring about $.7 \times 1.2$ mm. with a thin covering of distorted bark, there being little other hypertrophied tissue present. Usually covered with gray pubescence. On *Quercus prinoides* (and *Q. alba*?).

COTYPES.—Cotype females, males, and galls in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

These galls are very inconspicuous productions, hardly to be observed until the tiny exit holes made by the insects may be found in the stems of the flower clusters. The insects emerge late in May and early in June, after only a month spent in the galls. Bassett found the adults mostly emerged by June 10.

***Neuroterus tectus* form *abundans*, new name**

FEMALE.—Closely resembles the female of the bisexual generation, but has the abdomen darker in color and decidedly larger and more oval rather than triangular. LENGTH: 1.2-1.5 mm.

GALLS.—Not certainly identified. Most likely swellings very similar to the galls of the bisexual generation, but on the midvein of the young leaves, somewhat distorting the whole leaf.

COTYPES.—Cotype females in The American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, and the Museum of Comparative Zoology.

The eggs which produce this form of the species are laid early in June by the female of the bisexual generation. It is not certain what sort of galls are produced. Galls of the above description, in the Thompson Collection, belong, I believe, to the females of this generation, but the data was not distinctly affixed. From what is known of the life history of the species, it is evident that this generation lives in the galls for about ten and a half months, emerging and ovipositing April 29 (Bassett) to May 10 (Thompson). As far as known, the generation is agamic. The females very closely resemble the females of the bisexual generation but are readily distinguishable by the larger, more oval abdomen, a character to be expected in the agamic generation.

The material on which I base this data was obtained by the late Millett T. Thompson, whose collection of gall-insects is now in the Museum of the Boston Society of Natural History. The females marked "F" in the collection were found ovipositing May 10, 1907, in buds of *Quercus prinoides*, the points of oviposition were marked, the galls produced were bred and the females and males of the bisexual generation obtained. This material, distinctively labelled, is now in the Boston Society collections and in the author's collections.

These observations are in accord with those made by Bassett concerning the similarity of the two generations as he had found them, but Bassett did not mark the points of oviposition of the agamic form, nor did he note the differences in the two generations and keep them separate in his collections. The female "*tectus*," as Bassett described it, was apparently the agamic female, but the description of the abdomen as "small, in outline an equilateral triangle," applies distinctly to the female of the bisexual generation; while among the Bassett cotypes are females of both generations. Inasmuch as the male and the distinctive gall of the bisexual generation were called *tectus*, I use that name to designate that generation, and *abundans*, describing the larger-bodied female, for the agamic generation.

I feel fortunate in being able to present the life history of this species, because it gives another instance of the very slight differences between the successive generations of the species of *Neuroterus* and, further, bears out my belief that alternation of generations is merely a development of seasonal dimorphism. It is very much to be desired that we closely observe other species of *Neuroterus* and try to discern still more prim-

itive instances of dimorphism, or of a double-brooded condition without an accompanying heterogeny, among the species of the group.

***Andricus futilis* (Osten Sacken)**

RANGE.—Ontario (Jarvis). New Hampshire: Wolfeboro. Massachusetts: Magnolia (Clarke); Boston, Blue Hills, Sharon, Marthas Vineyard; Springfield (Stebbins). Connecticut: Waterbury (Bassett). New York: New York City (Beutenmüller). New Jersey: throughout (Smith). Pennsylvania: Shawnee (Thompson). District of Columbia: Washington (Osten Sacken). Maryland: Plummer's Is. (Weld). Ohio: Sandusky (Sears). Indiana (Cook). Illinois: Fort Sheridan (Weld). Michigan: Ionia Co. (Gillette).

***Andricus futilis* form *futilis* (Osten Sacken)**

Plate XXX, Figures 28 and 29

- Cynips quercus futilis* OSTEN SACKEN, 1861, Proc. Ent. Soc. Phila., I, p. 64.
Cynips quercus papillata OSTEN SACKEN, 1861, idem, I, p. 64.
Cynips q. futilis BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 329; 1873, Can. Ent., V, p. 92; 1873, Proc. Ent. Soc. Lond., p. xv.
Cynips futilis OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 339.
Cynips futilis OSTEN SACKEN, 1865, idem, IV, pp. 346, 349, 352, 355.
Cynips papillata OSTEN SACKEN, 1865, idem, IV, pp. 339, 346, 349, 352, 355.
Andricus futilis OSTEN SACKEN, 1865, idem, IV, p. 379. GILLETTE, 1889, Psyche, V, p. 185. DALLA TORRE, 1893, Cat. Hymen., II, p. 88. JARVIS, 1908, Report Ent. Soc. Ont., p. 86, Pl. B, fig. 4. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 27; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 13, fig. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 710; 1918, N. Y. State Mus. Bull. CC, p. 88, fig. 83, Pl. II, fig. 3. COOK, 1910, Mich. Geol. & Biol. Surv. Publ. I, p. 27. SEARS, 1914, Ohio Nat., XV, p. 381, fig. 21.
Andricus papillata OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 379.
Andricus (Callirhytis) futilis MAYR, 1881, Gen. Gallenbew. Cynip., p. 28. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 294, 295. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 254, Pl. II, fig. 1. VIERECK, 1916, Hymen. Conn., p. 433.
Cynips (Andricus) papillata PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.
Cynips (Andricus) futilis PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.
Andricus (Callirhytis) papillatus ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 295. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 255.
Callirhytis futilis ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 303; 1887, idem, XIV, p. 129. BASSETT, 1889, Psyche, V, pp. 235-237. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. RILEY, 1895, Sci., I, p. 461; 1895, Proc. Ent. Soc. Wash., III, p. 261. DALLA TORRE AND KIEFFER, 1910, Gen. Ins., Hymen., Cynip., p. 66. SMITH, 1910, Ins. New Jersey, p. 601. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 27. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. v, fig. 49. LUTZ, 1918, Field Book Ins., p. 462, Pl. xcvi, fig. 4.
Callirhytis papillatus ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. COOK, 1902, Ohio Nat., II, p. 269, fig. 30; 1903, idem, III, p. 427, fig. 64; 1904, idem,

IV, pp. 119, 124, 126, 127, 133, 141, 143, figs. 81, 107. SMITH, 1910, Ins. N. J., p. 601. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. iv, fig. 57. LUTZ, 1918, Field Book Ins., p. 462, Pl. xcvi, fig. 7.

Andricus papillatus PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 109. DALLA TORRE, 1893, Cat. Hymen., II, p. 93. BEUTENMÜLLER, 1904, Bull. Amer. Mus. Nat. Hist., XX, p. 28; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 14, fig. COOK, 1905, 29th Report Geol. & Nat. Res. Ind., p. 827, fig. 20. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 712; 1918, N. Y. State Mus. Bull., CC, p. 88, Pl. II, fig. 6.

Callirhytis papillata DALLA TORRE AND KIEFFER, 1910, Gen. Ins., Hymen., Cynip., p. 66. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 31.

Callirhytis quercus-futilis DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 584, fig. 325.

Callirhytis quercus-papillata DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 584.

Dryophanta papula [error] THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 13, Pl. iv, fig. 270.

? *Neuroterus* sp. [error] THOMPSON, 1915, idem, p. 59, Pl. xv, fig. 15.

[*Andricus papillatus* JARVIS, 1908, Report Ent. Soc. Ont., p. 91; 1909, idem, p. 87, Pl. c, fig. 5 = wrong determination.]

FEMALE.—Generally reddish brown or piceous, antennæ yellow, darker apically; mesopleuræ in part smooth and shining; wing-veins light brown, areolet small; length about 1.5 mm. HEAD: golden to dark, reddish brown, brightest on the face, darker toward the mouth, mouth-parts golden; coriaceous; antennæ 14-jointed, golden yellow, darker apically, hairy. THORAX: dark reddish- or piceous-brown; mesonotum regularly coriaceous; parapsidal grooves continuous to the pronotum, convergent at the scutellum; median groove indistinct beyond the middle of the mesothorax, anterior parallel lines indistinct, extending half the length of the mesothorax; lateral grooves shallow, indistinct; scutellum rugose, two shallow foveæ at base finely rugose; pronotum and mesopleuræ finely rugose, the latter in part smooth and shining. ABDOMEN: golden, rufous, or rufo-piceous, brighter basally, smooth and shining, the second segment covering only about half the abdomen. LEGS: reddish brown, hairy, the tarsal claws simple. WINGS: narrow, veins brownish yellow, not heavy; areolet small; cubitus faint, hardly reaching the basal vein, radial cell long and narrow, open; the first abscissa of the radius slightly angulate. LENGTH: 1.5–2.0 mm.

MALE.—Differs from the female in being darker, the antennæ 15-jointed, the second abdominal segment larger.

[Redescribed from bred Massachusetts material, galls and males compared with types.]

GALLS.—Blister-like swellings (Figs. 28 and 29) of the leaf-blades, more or less globular, projecting only slightly on the upper surfaces, projecting in about half a hemisphere on the lower surfaces. Leaf-color, sometimes surrounded by a reddish ring on the surface of the leaf; about 3–7 mm. in diameter. Thin-shelled, hollow, with usually 2 or 3 small larval cells, distinct, central, connected with the outer wall of the gall by fine, silky, radiating fibers. On leaves of *Quercus alba*, *Q. bicolor*, *Q. prinoides*, *Q. Prinus*, and *Q. stellata*.

COTYPES.—Cotype males and galls of both *futilis* and *papillatus* in the Museum of Comparative Zoology, and "type" galls in The American Museum of Natural History.

Osten Sacken did not feel certain of the specific differences of *futilis* and of *papillatus*; the main reason for which the two have been kept distinct is the reddish ring sometimes found around the galls called *papillatus*, and the different host plants of the two. I have compared the types of the two species and believe them to be identical. At the most, *papillatus* may be a host variety of *futilis*. As far as I can discover, the female of this species has not been previously described. It is quite variable as to shade of coloring.

The galls of *futilis* are first discernible about the middle of May, and are then to be found often very abundantly, on the white oak especially, sometimes occurring in numbers on a single leaf. The galls are at first so succulent that they are not easily bred; they should be gathered late in June and be placed directly on moist sand. The adults emerge from the last of June to the middle of July, leaving the empty galls now dry, hard, and brittle. The insects are positively geotropic and, after copulation, oviposit in the bark of the roots or the bases of the trunks of the white oaks.

***Andricus futilis* form *radicicola* (Dalla Torre)**

Plate XXX, Figure 27

Callirhytis radialis (non Fabricius, 1798) BASSETT, 1889, Psyche, V, p. 237. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66. SMITH, 1910, Ins. N. J., p. 601. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 571. FELT, 1908, N. Y. State Mus. Bull., CC, p. 54.

Andricus radicicola DALLA TORRE, 1893, Cat. Hymen., II, p. 95.

Andricus (*Callirhytis*) *radialis* VIERECK, 1916, Hymen. Conn., p. 426.

FEMALE.—Bright rufous and darker rufo-piceous; mesopleuræ mostly aciculate with some smooth and shining areas; abdomen with a ring of dense, whitish hairs at the base; areolet of moderate size. HEAD: bright rufous to dark piceous, slightly darker on the vertex; tips of mandibles piceous; very finely rugose, the face from the bases of the mandibles to the tips of the jaws densely hairy, rest of the head finely pubescent; antennæ 14-jointed, remarkably short, uniformly yellowish rufous or rufous, or somewhat darker distally, densely hairy. THORAX: bright reddish to reddish brown or dark piceous, variable; mesonotum brightest in the center toward the scutellum, densely rugoso-punctate, somewhat striate toward the sides; parapsidal grooves continuous to the pronotum, convergent toward the scutellum, deep, hardly smooth; median groove deep at the scutellum, traceable beyond the middle of the mesothorax to the pronotum; anterior parallel lines close together, smooth, extending half-way to the scutellum; lateral lines smooth, two-thirds the length of the mesothorax, approaching the parapsidal grooves anteriorly. Scutellum almost circular, brighter rufo-piceous, irregularly rugose, the two distinct foveæ at the base smooth; pronotum piceous, rufous anteriorly, rugose, hairy; mesopleuræ piceous black, mostly aciculate, smooth and shining along the posterior and the ventral edges; bright rufous at the bases of the wings. ABDOMEN: bright rufo-piceous, brighter basally; smooth and shining, two lateral patches and a ring of dense, whitish hairs at

the base of the second segment; this segment covering two-thirds of the abdomen, and somewhat produced dorsally. LEGS: rufous, the coxæ piceous basally, the hind coxæ almost entirely piceous; hairy, hairs densest on the tarsi; tarsal claws simple. WINGS: slightly tinged with yellowish, the veins light yellowish or almost colorless, except the subcostal and basal veins and the first abscissa of the radius which are light brownish yellow; areolet of moderate size or moderately large; cubitus very faint, not reaching the basal vein; radial cell open, broad; first abscissa of the radius angulate, not sharply so, without a projection into the radial cell. LENGTH: 2.7–3.7 mm.

[Redescribed from Bassett material bred from root-galls, and taken ovipositing in white oakbuds.]

GALLS.—Larval cells (Fig. 27) in the scurfy bark of the roots or the basal portions of the trunks of oaks. The cell-wall is distinct but inseparable from the surrounding bark-tissue which does not seem to have much new tissue developed, but is distorted to cover the larval cell, forming pustules about 3–4 mm. in diameter. On the same species of oak, most likely, on which *futilis* occurs.

In 1873 Bassett reported finding a number of wasps of an unknown species ovipositing in the buds of white oaks, which trees bore, at a later date, quantities of the galls of *futilis*. This alone was not sufficient evidence to warrant conclusions, for *futilis* is often exceedingly abundant on the majority of *Q. alba* trees in a region. But by 1889 he was able to report a more complete life history of the species. He had found hundreds of females which agreed with those he had bred from root-galls ovipositing in the buds of trees which later bore *futilis*-galls in abundance and only those galls. This evidence for the relation of the root-gall to the *futilis*-gall does not invite much doubt. The agamic form which had come from the root-galls was described as *radicis*.

The eggs which produce this form were laid in the bark during July. Because of the difficulty of finding these inconspicuous, subterranean galls, little is known of the form until it emerges as an adult the following spring, from April 22 to April 25 and likely later. At such times they are often found ovipositing in the buds of the white oaks, on the new leaves of which the *futilis*-galls will appear.

In 1895 (Proc. Ent. Soc. Washington, III, p. 261) Riley reported the rearing of *futilis* galls by Pergande from buds which he had observed being pricked by several females of a cynipid which Ashmead identified as *Callirhytis clavula*. Riley suggested, therefore, that Bassett's observations were in error because of misidentification. On the other hand, it is to be noted that the value of Riley's record depends on the correctness of Ashmead's identification. I have carefully examined numbers of the very specimens on which Bassett based his report, and they are available to others who wish to study them. I cannot see any specific differences between the individuals bred from root-galls and those marked as "ovi-

positing in *Q. alba* buds, April 22, 1889." Moreover, my own experience with *C. clavula* leads me to doubt the correctness of Riley's report. I know of no published dates of the emergence of that species but, having collected many hundreds of the galls, examining them for enclosed larvæ or adults regularly for a couple of years, I have found nothing to suggest that the imago emerges before the middle or last of July, at which time (July 27) I have been successful in obtaining several adults. Mr. Lewis H. Weld and Wm. Beutenmüller have kindly confirmed my experience by similar records from their own observations, July 12 to July 30 being the emergence dates from their breedings. It is not likely that Riley's insects, found ovipositing three months earlier than *clavula* emerges, could be that species. I have no doubt that there is an error in Riley's report and that Bassett's observations of this species are correct.

***Andricus operator* (Osten Sacken)**

RANGE.—Canada: Ottawa (Beutenmüller). Massachusetts: Boston (Clarke); Blue Hills, Sharon; Springfield (Stebbins). Rhode Island: Providence (Thompson). Connecticut: Waterbury (Bassett). New York: Sullivan Co. (Beutenmüller); Staten Island (W. T. Davis). New Jersey: Plainfield, New Brunswick, Milltown. Davis, Hornerstown (in Coll. Amer. Mus. Nat. Hist.). Pennsylvania (Beutenmüller). District of Columbia (Osten Sacken). Illinois (Walsh).

***Andricus operator* form *operator* (Osten Sacken)**

Plate XXXI, Figure 32

Cynips quercus operator OSTEN SACKEN, 1862, Proc. Ent. Soc. Phila., I, p. 256.

Cynips q. operator BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 332; 1864, idem, III, pp. 197, 198. WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 494. BASSETT, 1873, Can. Ent., V., pp. 91, 93, 94; 1877, Can. Ent., IX, p. 121. RILEY, 1873, Amer. Nat., VII, p. 519. HOWARD, 1882, Psyche, III, p. 329. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 11.

Cynips operator OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, pp. 341, 346, 350, 357.

[No name] BASSETT, 1880, Can. Ent., XII, p. 170.

Andricus (Callirhytis) operator MAYR, 1881, Gen. Gallenbew. Cynip., p. 28. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 294. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. VIERECK, 1916, Hymen. Conn., p. 429.

Callirhytis operator ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 304; 1887, idem, XIV, p. 131. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 110. RILEY, 1895, Sci., I, p. 463. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 25, fig. 47. SMITH, 1910, Ins. N. J., p. 601. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 11, 30, Pl. II, fig. 169. FELT, 1918, N. Y. State Mus. Bull., CC, p. 72.

Andricus operator DALLA TORRE, 1893, Cat. Hymen., II, p. 92. BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 315. FELT, 1906, Ins. Aff. Pk. and Woodl. Trees, II, pp. 618, 622, 713.

Callirhytis quercus-operator DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 582.

FEMALE.—Generally bright brownish, rufous, median groove essentially lacking; several of the wing-veins very faint, the terminal portion of the subcosta almost lacking, areolet closed. **HEAD:** bright brownish rufous, darker toward the cheeks and vertex, tips of mandibles piceous; finely shagreened, a broad median elevation on the face; antennæ 12–13-jointed, the last division sometimes obscure, uniformly light brownish rufous, glabrous, the first joint obconical, the second ovate, the third elongate and the longest segment. **THORAX:** bright brownish rufous, irregularly darker in places; glabrous; the mesonotum finely, shallowly shagreened; parapsidal grooves punctate, widely separated, hardly at all convergent at the scutellum, divergent at the pronotum; median groove faint or lacking; anterior parallel lines fine, not very distinct, extending half-way to the scutellum; lateral grooves almost parallel to the parapsides, extending over half the way to the pronotum. Scutellum rather circular, rugose, the two foveæ broad, deep, shining but sparsely rugose, separated by only a fine ridge; pronotum finely punctate-shagreened, the mesopleuræ finely shagreened to striate ventrally. **ABDOMEN:** rich rufous, brighter basally, darker apically and dorsally, essentially smooth and shining, very microscopically punctate; the second segment covering two-thirds of the abdomen; the sheaths of the ovipositor pointing almost vertically. **LEGS:** rather uniformly rufous brown; the tarsal claws darker, simple. **WINGS:** clear, the wing-veins, especially on the basal half of the wings, light brown, terminal portion of the subcosta very faint or lacking; areolet closed; cubitus not reaching the basal vein; the radial cell open; the first abscissa of the radius angulate, the angle about 120°, without a projection into the radial cell. **LENGTH:** 2.2–2.5 mm.

MALE.—Similar to the female, but more generally yellowish rufous, the antennæ light yellowish rufous, 14-jointed, the third joint incised beneath; the abdomen bright yellowish rufous basally, almost black posteriorly, smaller and more slender, the second segment covering most of the abdomen; length, 1.7–2.2 mm.

[Redescribed from Massachusetts material bred in a series of over 600 individuals.]

GALLS.—Large, compact masses (Fig. 32) of wool containing seed-like larval cells. The clusters are irregular in shape, often oval, 4×5.5 cm., more or less, in dimensions, the hairs at first crisp, succulent, greenish, white, or rose-tinged, sometimes deep red, becoming yellowish brown with age, finally weathering bluish gray or black and drying into a shrivelled mass. Within the wool, scattered or in small clusters, are the larval cells, hard and rather thick-walled, oval, about 1.5×3 mm., distributed mostly but not entirely toward the center of the gall. On and involving the young terminal stems, new clusters of leaves, and especially the flower clusters of *Quercus coccinea*, *Q. ilicifolia*, *Q. marylandica*, *Q. palustris*, *Q. rubra*, *Q. velutina*, and likely related oaks.

COTYPES.—Cotype females and galls in the Museum of Comparative Zoology.

The gall of this form is a very abundant early-spring gall in scrub-oak country, appearing with the flowers of the oaks about the middle of May and growing rapidly. It should not be gathered for breeding until after the first of June, for it is succulent when first formed and dries and dies unless nearly mature when gathered. The woolly hairs, Bassett has

pointed out, are merely a much modified leaf pubescence. The galls, after the emergence of the adults, become much the worse for weathering and by autumn only fragments of the wool remain upon the trees. The galls often bring great numbers of the insects to maturity; from three galls I obtained 578 adults which emerged from June 9 to June 30. The sexes are produced in about equal numbers. The females, as Bassett discovered, deposit the eggs in the acorns of the scrub-oaks, inserting the ovipositor between the nut and the cup of the very small, young acorns. The gall produced is the form *operatola*.

***Andricus operator* form *operatola* (Bassett)**

Plate XXXI, Figures 30 and 31

Cynips q. operatola RILEY, 1873, Amer. Nat., VII, p. 519 [Adult not described].

Callirhytis operatola RILEY, 1895, Sci., I, p. 463. THOMPSON, 1915, Cat. Amer. Ins.

Galls, pp. 21, 30, Pl. II, fig. 169.

Andricus operatola BASSETT, 1900, Trans. Amer. Ent. Soc., XXVI, p. 315 [Adult first described]. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 62;

1910, Das Tierreich, XXIV, p. 550. BEUTENMÜLLER, 1913, Bull. Brooklyn Ent. Soc., VIII, p. 103, fig. 8. VIERECK, 1916, Hymen. Conn., p. 418.

Andricus operator form *operatola* FELT, 1906, Ins. Aff. Pk. and Woodl. Trees, II, p. 709.

Callirhytis operator STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 26, fig. 48.

Andricus operator FELT, 1918, N. Y. State Mus. Bull., CC, p. 118, Pl. II, fig. 5.

FEMALE.—Generally rufous; median groove faint or lacking; mesopleuræ rather heavily aciculated; second abdominal segment hairy; several wing-veins faint, the terminal portion of the subcosta lacking. **HEAD:** rufous, the tips of the mandibles piceous; coriaceous or shagreened; face and cheeks finely hairy; antennæ rufous, irregularly marked brown, 12-13-jointed, third joint the longest, twelfth joint obscurely divided. **THORAX:** bright rufous, irregularly darker on the anterior parallel lines, at the edges of the thoracic plates, and elsewhere; mesonotum punctate to finely rugulose, with appressed hairs; parapsidal grooves punctate, widely separated and hardly convergent at the scutellum, divergent at the pronotum; median groove very faint or lacking; anterior parallel lines extending half-way to the scutellum; the lateral grooves sinuous, short and smooth; scutellum almost circular, rugose hairy, the foveæ at the base are shining but sparsely rugose, separated by a not broad ridge; pronotum coriaceous; the mesopleuræ rather heavily aciculated. **ABDOMEN:** bright rufous, brightest basally, darker dorsally and posteriorly, essentially smooth and shining, only microscopically punctate, the second segment with appressed hairs basally and largely over the sides; second segment covering three-quarters of the abdomen, considerably produced dorsally. **LEGS:** rufous, not uniformly so, hairy, the tarsal claws darker, simple. **WINGS:** veins reddish brown, the terminal part of the subcosta faint or lacking, the second abscissa of the radius, the cubitus, and the discoideus very faint; areolet rather small or lacking; the cubitus continuous to the basal vein but hardly apparent; the radial cell open; the first abscissa of the radius angulate, the angle about 120° without a projection into the radial cell. **LENGTH:** 3.2-3.5 mm.

[Redescribed from material Bassett found ovipositing May 4, 1873, to produce the woolly gall.]

GALL.—A small, seed-like gall (Figs. 30 and 31) at the base of the nut of the acorn, inside the cup. The gall suggests a development of the aborted ovule of the acorn, but sometimes five or six occur in a single acorn. It is a compressed, inverted cone in shape, about 5 mm. high by 4 mm. in diameter, larger or smaller, and is thin-walled, the larval cell occupying most of the gall. In the acorns of *Quercus ilicifolia* and of the other red oaks on which the bisexual form occurs.

COTTAGES.—In the collections of The American Museum of Natural History and of the Academy of Natural Sciences of Philadelphia.

The agamic female is in many detailed respects quite similar to the female *operator*. It is similar in head and thoracic sculpture, peculiarities of coloration, wing venation, etc., and is to a certain extent merely an enlarged edition of *operator*, with, of course, enough "specific" differences. The most remarkable character of the heterogeny of this species really lies in the very great differences of the galls of the two generations, and even this does not appear so remarkable when one considers the totally different natures of the parts of the plant affected.

The gall of *operatola* usually escapes detection until the fall, when the growing gall projects beyond the rim of the acorn cup and often splits or otherwise deforms the nut of the acorn. These galls fall to the ground, sometimes fixed in place, more often broken out of the fruit, so that acorns bearing the scars of the galls may be found abundantly under scrub-oaks. The galls are highly parasitized and are often much damaged by wintering on the ground—another instance of the poor quality of the "protection" afforded a gall-wasp. Consequently, it is a difficult matter to rear the adults of this form. Bassett states that the insects may mature the following spring or may remain in the galls until the second or even third spring before they emerge. He found them emerging May 4 and ovipositing in the young buds of the oaks.

Bassett's observations of this species finally led to the first absolute proof that heterogeny occurred in the Cynipidæ. A detailed account of the discovery has been given on page 324. Adults have been bred from galls of both generations and each of these have been observed to oviposit to produce the galls of the other generation. Bassett's observations were apparently made in the open, but his definite statements would indicate that the pricked parts were definitely marked for later identification.

***Andricus palustris* (Osten Sacken)**

RANGE.—Canada: Ottawa (Provancher); Toronto (Cosens). Maine (Patch). Massachusetts: Magnolia (Clarke); Boston; Springfield (Stebbins); Marthas Vineyard. Rhode Island: Providence (Thompson). Connecticut: New Haven (Walden); Waterbury (Bassett). New York: Cypress Hill, Nyack (Zabriskie); New York City (Beutenmüller). New Jersey (Smith); Fort Lee, Mattawan (Beutenmüller). Pennsylvania (Beutenmüller). District of Columbia: Washington (Osten Sacken).

Ohio (Beutenmüller). Indiana (Cook). Illinois (Walsh). Michigan (Beutenmüller). Iowa: Ames (Gillette).

***Andricus palustris* form *palustris* (Osten Sacken)**

Plate XXX, Figures 23 and 24

- Cynips q. palustris* OSTEN SACKEN, 1861, Stett. Ent. Zeit., XXII, pp. 409, 412; 1865, Proc. Ent. Soc. Phila., IV, pp. 343, 346, 349. BASSETT, 1863, Proc. Ent. Soc. Phila., II, p. 329. WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 488.
- Cynips quercus palustris* OSTEN SACKEN, 1861, Proc. Ent. Soc. Phila., I, pp. 51, 62; 1865, Proc. Ent. Soc. Phila., IV, p. 359; 1870, Trans. Amer. Ent. Soc., III, p. 54. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 113.
- Cynips (Trigonaspis ?) quercus palustris* OSTEN SACKEN, 1861, Proc. Ent. Soc. Phila., I, p. 63.
- Cynips q. notha* OSTEN SACKEN, 1870, Trans. Amer. Ent. Soc., III, p. 55. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 28.
- Andricus (Callirhytis) palustris* MAYR, 1881, Gen. Gallenbew. Cynip., p. 28. BASSETT, 1882, Amer. Nat., XVI, p. 246. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 294. PROVANCHER, 1886, Addit. Fauna Canad. Hymen., p. 54. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 256. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 30.
- Andricus (Callirhytis) notha* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 295. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 105.
- Callirhytis notha* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 304. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 110. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66.
- Callirhytis palustris* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 304. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 110. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 66. STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, pp. 21, 23, 26, fig. 37. SMITH, 1910, Ins. N. J., p. 601. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 14. LUTZ, 1918, Field Book Ins., p. 462, Pl. xcvi, fig. 11.
- Dryophanta notha* ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. DALLA TORRE, 1893, Cat. Hymen., II, p. 53. BEUTENMÜLLER, 1911, Bull. Amer. Mus. Nat. Hist., XXX, p. 366, Pl. xvi, fig. 4. THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 38. FELT, 1918, N. Y. State Mus. Bull., CC, p. 106, fig. 68, 4.
- Dryophanta palustris* ASHMEAD, 1887, Trans. Amer. Ent. Soc., XIV, p. 129. CRESSON, 1887, idem, XIV, Suppl., p. 179. BASSETT, 1890, idem, XVII, p. 74. DALLA TORRE, 1893, Cat. Hymen., II, p. 53. COOK, 1902, Ohio State Univ. Bull., Ser. 6, p. 268, fig. 29; 1903, idem, Ser. 7, p. 427, fig. 65; 1904, idem Ser. 8, figs. 82, 84, 84b, 94. BEUTENMÜLLER, 1911, Bull. Amer. Mus. Nat. Hist., XXX, p. 361, Pl. xv, figs. 1-4, Pl. xvii, figs. 1-2. COSENS, 1912, Trans. Can. Inst., IX, p. 344, figs. 49-52. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 21, 38, Pl. i, fig. 167. FELT, 1918, N. Y. State Mus. Bull., CC, p. 90, figs. 86, 87 (1-4).
- Andricus palustris* PROVANCHER, 1889, Add. et correct., p. 163. BEUTENMÜLLER, 1904, Amer. Mus. Journ., IV, p. 101, fig. 26; 1904, Amer. Mus. Nat. Hist. Guide Leaf. 16, p. 15, fig. COOK, 1905, 29th Report Dept. Geol. & Nat. Hist. Ind., p. 829, fig. 22. JARVIS, 1906, 37th Report Ent. Soc. Ont., p. 71. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 714. VIERECK, 1916, Hymen. Conn., p. 419.

- Andricus (Callirhytis) pusulatoides* BASSETT, 1890, Trans. Amer. Ent. Soc., XVII, p. 74.
- Andricus pusulatoides* DALLA TORRE, 1893, Cat. Hymen., II, p. 94. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 712.
- Neuroterus notha* ASHMEAD, 1899, Proc. Ent. Soc. Wash., IV, p. 332.
- Callirhytis pustulatoides* DALLA TORRE AND KIEFFER, 1902, Gen. Ins. Hymen., Cynip., p. 66; 1910, Das Tierreich, XXIV, p. 570.
- Callirhytis quercus-palustris* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 565.
- Callirhytis quercus-notha* DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 565.
- Callirhytis pusulatoides* STEBBINS, 1910, Springfield (Mass.) Mus. Bull., II, p. 23. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 14, 30.
- Cynips notha* THOMPSON, 1915, Cat. Amer. Ins. Galls, p. 14.
- Andricus (Callirhytis) pustulatoides* VIERECK, 1916, Hymen. Conn., p. 433.

The following are very likely synonyms of *Andricus palustris palustris*:

- Cynips q. aquatica* ASHMEAD, 1881, Trans. Amer. Ent. Soc., IX, p. xvi [Florida].
- Spathogaster q. laurifoliae* ASHMEAD, 1881, idem, IX, p. xvii [Florida].
- Andricus (Callirhytis) quercifoliae* ASHMEAD, 1885, idem, XII, pp. 295, 299 [Florida].
- Dryophanta liberocellulae* GILLETTE, 1889, Iowa Agric. Exp. Sta. Bull., VII, p. 283, fig. 27 [Iowa, Michigan].

FEMALE.—Head, thorax, and abdomen black; antennæ brown, yellow basally; the legs a dull amber-brown; mesonotum shining, almost smooth, the parapsidal grooves distinct, other lines lacking; wing-veins heavy, the areolet of moderate or small size. **HEAD:** black, reddish on the mouth-parts, finely coriaceous, the face with a few scattered hairs; antennæ 14-jointed, dark brown, the first three or four joints dull amber-yellow. **THORAX:** black, mesonotum finely coriaceous but appearing almost smooth and shining; parapsidal grooves broad, deep, continuous to the pronotum; median groove very short or lacking; anterior parallel lines and lateral lines lacking; scutellum black, elongate, rugoso-punctate, the shallow foveal depression at the base coriaceous; pronotum almost smooth; mesopleuræ slightly rugose. **ABDOMEN:** black, smooth, shining, the second segment "tongue shaped," i. e., produced dorsally. **LEGS:** dull amber-yellow or brown, the tips of the tarsi almost black; hairy; the tarsal claws simple. **WINGS:** clear, the veins dark brown, areolet small, cubitus not quite reaching the basal vein; radial cell open; the first abscissa of the radius slightly angulate, without a projection into the radial cell. **LENGTH:** 1.8-2.3 mm.

MALE.—Similar to the female, but with the antennæ 15-jointed, the third joint somewhat thickened apically and appearing slightly curved; the abdomen small and petiolate.

[Redescribed from material bred in life-history experiments, and compared with types.]

GALLS.—Globular, entirely hollow, succulent galls (Figs. 23 and 24) the size of a cherry, containing a free larval cell. The galls average about 3-12 mm. in diameter, are green or rose-tinged, very succulent, quickly shrivelling or decaying, and are entirely glabrous or in other instances roughened or densely but finely pubescent, depending upon the nature of the host. The mature gall is thin-walled, entirely hollow, more or less filled with a liquid, and contains a single larval cell, whitish,

averaging 2.0 mm. in diameter, hard but thin-walled, entirely free, rolling about within the gall. Singly or in clusters, sometimes somewhat fused together, on the young buds, aments, petioles, and leaf-blades of oaks, sometimes only slightly attached, at other times inseparable from the leaf-tissue. On *Quercus coccinea*, *Q. falcata*, *Q. ilicifolia*, *Q. imbricaria*, *Q. marilandica*, *Q. palustris*, *Q. phellos*, *Q. rubra*, *Q. velutina*, and most likely other red oaks.

COTYPES.—Cotype females, males, and galls in the collection of the Museum of Comparative Zoology.

I have examined the types of *Andricus notha* (Osten Sacken) and the adults appear to be true *palustris*. The galls are somewhat more oval in shape, with the larval cell more elongate, but I have found that that character shows gradations in large series of *palustris* and there is little doubt that *notha* is, as Osten Sacken strongly suspicioned, not distinct. Beutenmüller makes *Andricus pusulatooides* Bassett a synonym of *notha*. Beutenmüller (1911, Bull. Amer. Mus. Nat. Hist., XXX) also says that he cannot find essential differences between true *palustris* and the types of *Dryophanta aquatica*, *D. laurifoliae*, and *D. liberae-cellulae* but, because of lack of sufficient material, he prefers to consider them distinct. I can hardly see any justification for keeping those names out of the synonymy.

The gall of *Andricus palustris palustris* is one of the best-known of the galls of early spring, appearing abundantly on red oaks of many species, often before any leaves have appeared. They often crowd closely on the flowers of the oaks. When the galls first appear they are solid, with the larval cell distinct but entirely connected with the outer walls of the gall; but within a very few days or even hours the gall, growing very rapidly, becomes hollow leaving the larval cell (which had gained its full size in the young gall) loose to roll about within the enlarged outer wall at every movement of the branches of the tree. How the nourishment is provided for the larval cell and the enclosed larva is a process yet to be studied. During damp weather the galls will be found to contain a more or less viscous liquid, and placed in a pan of water they become filled with this liquid. It is probable that food is carried by osmosis to the larval chamber. Galls taken from the tree will grow still larger if placed directly on very moist sand or in water, indicating how independent an organism these deformations may become.

Because the galls are so very succulent they should not be gathered for breeding until they are about mature, and should then be placed directly on very moist sand. The growth of these galls is very rapid after their first appearance upon the trees and they are mature within

ten days or two weeks. The pupation period of the insect is very short; within a few days the adult emerges and within another few days the galls are mostly completely withered away or have decayed.

The adults emerge from mid-May to June 4, depending on the latitude and the progress of the season. The insects are produced in about equal numbers of the sexes. They copulate almost immediately upon emergence and run rapidly up the branches to the young leaves, on the under sides of which they settle to oviposit, often remaining there for several days before they die. In all, only about a month has passed from the time of the first appearance of the young gall to the time of oviposition. Over ten months will be required for the alternate generation to reach full maturity.

The experiments by which I was fortunate enough to discover the relations of the two generations of this species were made under the strictly controlled conditions which I have described in the introduction. The tree on which the sexual adults were put was covered with a net for almost a month and there was no chance of other insects having reached it during that time, nor is there much likelihood of the galls having been produced by insects from any other source. Of the thirty small oaks in the greenhouse, none produced any galls that season (1918) except the one on which the *palustris* had been isolated. Several scores of the adults of that form were observed to oviposit on the under surface of the leaves on which eight galls of *Philomix compressa* were found the first of September. The small size of the galls had prevented their detection earlier, for it is likely that they appear by the first of August.

P. compressa was a "species" known definitely from only two stations, Westchester Co., N. Y., and Ames, Iowa, while *palustris* had been known for sixty years to be a very abundant species throughout eastern America. It was rather surprising to find an apparently rare, local species to be the alternate form of one of the commonest of widely distributed galls. Fortunately, I recalled definitely the location of the very trees on which I had found the *palustris* galls from which the experimental material had been bred. I made a trip to these trees and found the leaves bearing an abundance of the *compressa* galls. Then I found the galls in the Millett Thompson Collection, taken in Massachusetts or Rhode Island; these were figured in the Thompson Catalogue but the collection was not recorded in the text. After that, I collected *compressa* galls at Melrose Highlands, Forest Hills, and Blue Hills, which are in the neighborhood of Boston, and always found it abundant at that date. The small size of the galls and the fact that they are very quickly decidu-

ous is sufficient explanation of the failure of previous collectors to find the form.

***Andricus palustris* form *compressus* (Gillette)**

Plate XXX, Figures 25 and 26

Acraspis compressus GILLETTE, 1891, Bull. Ill. Lab. Nat. Hist., III, p. 197.

Acraspis compressa DALLA TORRE, 1893, Cat. Hymen., Cynip., II, p. 64. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 58. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 409.

Philonix compressa BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 253. FELT, 1918, N. Y. State Mus. Bull., CC, p. 94.

Acraspis compressum THOMPSON, 1915, Cat. Amer. Ins. Galls., pp. 15, 35, Pl. iv, fig. 78.

FEMALE.—Wingless, small, ant-like, the head nearly twice as broad as the thorax, the abdomen compressed and very large, circular. **HEAD:** rufous, darker dorsally, very finely reticulate or regularly coriaceous; antennæ 14-jointed, rufous basally, shading into dark brown apically. **THORAX:** entirely rufous, coriaceous, very small and narrow, about one-half as wide as the head, not twice as long as wide; parapsidal grooves continuous to the pronotum but not very evident because of the small size of the mesothorax; other furrows lacking; scutellum very narrow, elevated posteriorly, with two very tiny foveæ at the base. **ABDOMEN:** rufous or rufo-piceous, brightest basally and dorsally; smooth and shining; very large, circular, strongly compressed, the second segment about one-half the length of the abdomen. **LEGS:** rufous to reddish brown, the hind legs darker. **WINGS:** entirely wanting. **LENGTH:** 2.5 mm.

GALLS.—Small, globular galls, (Figs. 25 and 26), 2–3 mm. in diameter, very slightly attached to the under surfaces (rarely the upper surfaces) of the leaves by a slight projection on the gall. White or pinkish, wax-like, solid and succulent at first, quickly deciduous, after which the gall enlarges and becomes brown, thin-walled, and hollow, the cavity constituting the larval cell. On the same species of red oaks, most likely, as the *palustris* gall.

TYPES.—At the Illinois State Laboratory of Natural History (Urbana, Illinois).

These minute galls are very quickly deciduous, falling in October or early November, usually before the leaves, to the ground where they undergo further development. The larva does not pupate until the next spring, a little time before emerging in April or early May, just before the time of appearance of *palustris* galls.

***Andricus fulvicollis* (Fitch)**

RANGE.—Ontario: Toronto (Cosens). Massachusetts (Clarke). Connecticut: Waterbury (Bassett). New York: New York City (Beutenmüller); Staten Island (Davis). New Jersey: Fort Lee, Paterson, New Brunswick (in Coll. Amer. Mus. Nat. Hist.). Pennsylvania: Philadelphia (Bassett). Virginia (Beutenmüller). North Carolina (Beutenmüller). Florida (?Beutenmüller). Ohio (Bassett). Indiana (Cook). Illinois (Walsh). Michigan: Lansing (Gillette). Iowa (Gillette). Kansas, (Bridewell). Oklahoma: Ben's Farm, Arkansas River (in Coll. Amer. Mus. Nat. Hist.). Colorado (?Ashmead).

Andricus fulvicollis form bicolens, new name

Plate XXXI, Figure 33

Dryophanta erinacei TRIGGERSON, 1914, Ann. Amer. Ent. Soc., VII, pp. 4-7, Pl. I, fig. 4, Pl. II, figs. 7, 9, 10, Pl. III, figs. 21-29, Pl. IX, fig. 70.

Cynips erinacei FELT, 1918, N. Y. State Mus. Bull., CC, p. 75.

FEMALE.—Generally piceous black; the parapsidal grooves not reaching the pronotum, lateral grooves broad and shallow, mesonotum otherwise about smooth, first abdominal segment only one-third the length of the abdomen. **HEAD:** black, rough, face sparsely hairy, mouth-parts yellowish brown; head not broadened behind the eyes; cheeks not half as long as the eyes; antennæ brown, lighter basally, hairy, 14-jointed, the first two segments considerably stouter than the following. **THORAX:** piceous black to black, mesonotum almost smooth, slightly roughened, coriaceous to finely rugose anterior of the parapsidal grooves; parapsidal grooves distinct, continuous almost but not entirely to the pronotum; median groove and anterior parallel lines lacking; lateral grooves broad and shallow, two-thirds the length of the pronotum; scutellum black, somewhat angulate in outline, finely rugose and finely hairy, with two, small, shallow, not smooth, divergent foveæ at the base; pronotum and mesopleuræ almost but not entirely smooth. **ABDOMEN:** piceous or brownish black, lightest basally, almost smooth, the second segment only about one-third the length of the whole abdomen. **LEGS:** clear amber-brown, hairy, the coxæ darker brown, the tarsal claws simple, brownish black. **WINGS:** tinged with yellowish, the veins light brown; areolet rather large; cubitus fainter than other veins but continuous to the basal vein; the radial area open; first abscissa of the radius angulate, slightly and limitedly clouded, the angle about 135°. **LENGTH:** 1.7-2.0 mm.

MALE.—Similar to the female; generally more brownish piceous; antennæ 15-jointed; legs lighter yellowish brown; abdomen smaller, petiolate; length, 1.5-1.7 mm.

[Redescribed from Illinois material bred by Mr. Lewis H. Weld.]

GALLS.—Small, thin-walled, elongate egg-shaped galls (Fig. 33), within the bud-scales. The galls are about 2-3 mm. long, all but microscopically smooth, monothalamous, thin-walled, yellowish brown, without a separate or even distinct larval cell; sometimes two or three galls will develop in the same bud-scale and become fused. In the bud-scales or ("*bicolens*") on the terminal portions of leaf and flower buds of *Quercus alba*.

TYPES.—?

In 1914 C. J. Triggerson reported from the Entomological Laboratory of Cornell University an account of the life history of this species, together with a study of its parasites and inquiline, and questions concerning the stimulus for gall formation. The observations on the life history of this wasp are more complete, and the evidence concerning the alternate generations more definite than for any other species of American cynipid, to date. Branches with buds in which the agamic form had oviposited were brought into the laboratory, where the adults of the second generation were bred from the galls. Oviposition of this generation was observed both in the laboratory and in the field, and later

at these points galls of the agamic generation were obtained and the agamic female was again bred. Triggerson's account furnishes many details of the life history of the species, and no attempt need be made here to give much more than descriptions of the galls and adults of the two generations.

According to Triggerson, the galls of this form were first visible about May 12; the adults emerge from May 21 (indoors) or May 29 (out-of-doors) until June 5. They oviposit immediately to produce the agamic generation.

***Andricus fulvicollis* form *erinacei* (Beutenmüller)**

Plate XXXI, Figure 34

- Philonix fulvicollis* FITCH, 1859, 5th Report on Noxious. . . Ins. N. Y., p. 783.
 OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 353. ASHMEAD, 1903, Psyche, X, p. 148. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, p. 711. BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 254; 1918, Ent. News, XXIX, p. 328. VIERECK, 1916, Hymen. Conn., p. 381.
- Cynips q. erinacei* WALSH, 1864, Proc. Ent. Soc. Phila., II, p. 483.
- Teras fulvicollis* OSTEN SACKEN, 1865, Proc. Ent. Soc. Phila., IV, p. 379.
- Cynips (Teras) fulvicollis* PACKARD, 1881, U. S. Ent. Comm. Bull., VII, p. 56.
- Acraspis erinacei* MAYR, 1881, Gen. Gallenbew. Cynip., p. 30. ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, p. 295; 1887, Trans. Amer. Ent. Soc., XIV, p. 128; 1890, Colo. Biol. Assoc. Bull., I, p. 38. GILLETTE, 1888, 27th Report Agric. Mich., p. 470; 1889, Psyche, V, pp. 186, 221; 1892, Proc. Iowa. Acad. Sci., I, part 2, p. 112. PACKARD, 1890, 5th Report U. S. Ent. Comm., p. 106. BEUTENMÜLLER, 1892, Bull. Amer. Mus. Nat. Hist., IV, p. 259, Pl. xii, fig. 1; 1904, Amer. Mus. Nat. Hist. Guide Leaflet 16, p. 18; 1904, Amer. Mus. Journ., IV, p. 104, fig. 35. DALLA TORRE, 1893, Cat. Hyman., II, p. 64. BRIDEWELL, 1899, Trans. Kans. Acad. Sci., XVI, p. 203. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 58. COOK, 1905, 29th Report Dept. Geol. & Nat. Res. Ind., p. 832, fig. 25; 1910, Mich. Geol. & Biol. Surv. Publ. 1, p. 28. JARVIS, 1906, 37th Report Ent. Soc. Ont., p. 70. FELT, 1906, Ins. Aff. Pk. & Woodl. Trees, II, pp. 619, 627. THOMPSON, 1915, Cat. Amer. Ins. Galls, pp. 15, 35. FAGAN, 1918, Amer. Nat., LII, p. 157. LUTZ, 1918, Field Book Ins., p. 462, Pl. xcvi, fig. 4.
- Biorrhiza fulvicollis* ASHMEAD, 1885, Trans. Amer. Ent. Soc., XII, pp. 296, 304. PACKARD, 1890, 5th Report U. S. Ent. Comm., pp. 106, 110. DALLA TORRE AND KIEFFER, 1910, Das Tierreich, XXIV, p. 402.
- Biorrhiza fulvicollis* DALLA TORRE, 1893, Cat. Hymen., Cynip., II, p. 60. DALLA TORRE AND KIEFFER, 1902, Gen. Ins., Hymen., Cynip., p. 56.
- Philonix erinacei* BEUTENMÜLLER, 1909, Bull. Amer. Mus. Nat. Hist., XXVI, p. 247 [first description of adult named *erinacei*], Pl. xliii, fig. 24. SMITH, 1910, Ins. N. J., p. 598. COSENS, 1912, Trans. Canad. Inst., p. 341, fig. 64.
- Acraspis quercus-erinacei* DALLA TORRE AND KIEFFER, 1910, Das Tierreich. XXIV, p. 413, fig. 118.

Philonyx fulvicollis SMITH, 1910, Ins. N. J., p. 598.

FEMALE.—Almost wingless; antennæ black, basal joints rufous; parapsidal grooves not quite reaching the pronotum; thorax densely hairy anteriorly and on the mesopleuræ; abdomen large, considerably elongate. **HEAD:** black, with a more or less large amount of rufous around the compound eyes and on the mouth-parts; rather finely rugose, more rugose toward the vertex and toward the mouth-parts; hairy; ant. nnæ 14-jointed, black, basal joints rufous. **THORAX:** mesonotum rufous, coriaceous or very finely rugose, very hairy anteriorly; parapsidal grooves indistinct, not quite extending to the pronotum, gradually convergent toward the scutellum; median groove very short but distinct; anterior parallel lines essentially absent; lateral grooves present, not deep; scutellum rufous, blackish basally, hairy, rugose, long and narrow, with a short, projecting spine terminally, the two, shallow, narrow foveæ at the base only finely separated; pronotum rugose, black, more or less rufous laterally, densely hairy; mesopleuræ black, aciculate to rugose, densely hairy. **ABDOMEN:** large, considerably elongate, piceous black, with more or less rufous, especially basally and terminally, hairy on the sides ventrally, densely hairy at the tip of the hypopygium and at the tip of the abdomen; second segment not quite one-half the total abdominal length. **LEGS:** rufous, hairy, irregularly darker in places; tarsal claws large, toothed. **WINGS:** rudimentary, not twice the length of the scutellum. **LENGTH:** 1.5–3.0 mm.

[Redescribed from Bassett material from Ohio and Connecticut.]

GALLS.—Oval leaf-galls (Fig. 34), densely covered with fine spines, reddish purple. The galls are globular or more often oval, 10×14 mm., more or less, the surface light yellowish, closely set with small, raised points, each tipped with a slender, thread like, flexuous spine 2 or 3 mm. long, yellowish, reddish purple, or blackish in color. Within, the tissue is compact-granular, the larval cells usually two or three (two to eight), each measuring about 1.5×2.0 mm., the cells distinct but inseparable. Attached by a single point to a main-vein, on the upper or under surfaces of leaves of *Quercus alba*.

TYPES.—Fitch's type "*fulvicollis*" is in the United States National Museum; the cotypes "*erinacei*," adults and galls, in The American Museum of Natural History, the Museum of Comparative Zoology, and in the collection of Mr. William Beutenmüller.

Beutenmüller is authority for the identity of *erinacei* and *fulvicollis*.

This gall appears in late June, becoming mature about the last of August, staying on the trees into October. The insects emerge from November 5 to 21, or even in early December, often when the weather is very cold, and snow is on the ground. The insect oviposits in the young buds of the oak trees. Fuller details of the habits of this species are given in Triggerson's paper.

In addition to the above data, studies of *Amphibolips confluens* (Harris)¹ and of a couple of species of *Neuroterus* have been reported, but I feel that the information is not sufficiently complete to warrant reporting life histories of those species until further studies have been made.

¹See Walsh, 1864, Proc. Ent. Soc. Phila., II, pp. 443-500.

BIBLIOGRAPHICAL NOTE

The synonymical bibliographies of each of the species here treated is sufficient guide to all but a few articles, references to which have been made in the preceding pages.

- ADLER, HERMANN. 1877a. Beiträge zur Naturgeschichte der Cynipiden. Deut. Ent. Zeit., XXI, pp. 209-248.
 1877b. Lege-Apparat und Eirlegen der Gallwespen. Idem, XXI, pp. 305-332.
 1881. Ueber den Generations-wechsel der Eichen Gallwespen. Zeitschr. f. wissensch. Zool., XXXV, pp. 151-246.
- ADLER AND LICHTENSTEIN. 1881. La Génération Alterante chez les Cynipides. Lichtenstein trans., edit., and publ. Montpellier.
- ADLER AND ST ATON. 1894. Alternating Generations. Straton trans. and edit., Oxford, Clarendon Press.
- BASSETT, HOMER F. 1864. [Communication to meeting of July 11, 1864.] Proc. Ent. Soc. Phila., III, pp. 197, 198.
 1873. On the Habits of Certain Gall Insects of the Genus *Cynips*. Can Ent., V, pp. 91-94.
- CHAMISSE, ADALBERT de. 1819. De Animalibus, I, De Salpa. Berlin.
- HARTIG, THEO. 1840. Ueber die Familien der Gallwespen. Zeitschr., f. d. Ent., II, p. 176.
- HOWARD, L. O. 1882. Alternate Generation in Cynipidæ. Psyche, III, pp. 328-329.
 1910. The Insect Book. New York, Doubleday, Page & Co., pp. 53-55.
- LICHTENSTEIN, J. 1881. (Cf. Adler and Lichtenstein.)
- OSTEN SACKEN, C. R. 1861. [Concerning the sexes of *Cynips*.] Proc. Acad. Nat. Sci. Phila., July 1861, September 1862.
 1865. Contributions to the Natural History of the Cynipidæ of the United States and of their Galls. Proc. Ent. Soc. Phila., IV, pp. 331-380.
- RILEY, C. V. 1873. Controlling Sex in Butterflies. Amer. Nat., VII, pp. 513-521.
 1895. Alternating Generations. Science, N. S., I, pp. 457-463.
- WALSH, B. D. 1864. On Dimorphism in the Hymenopterous Genus *Cynips* with an Appendix . . . etc. Proc. Ent. Soc. Phila., II, pp. 443-500.

PLATE XXVIII

Figs. 1 and 2. *Aylax glechomae* $\times 3$.

Figs. 3 and 4. *Rhodites rosae* $\times 1.5$; filaments partly removed.

Figs. 5 to 7. *Rhodites ignotus* $\times 2.5$; fig. 5, galls of second generation.

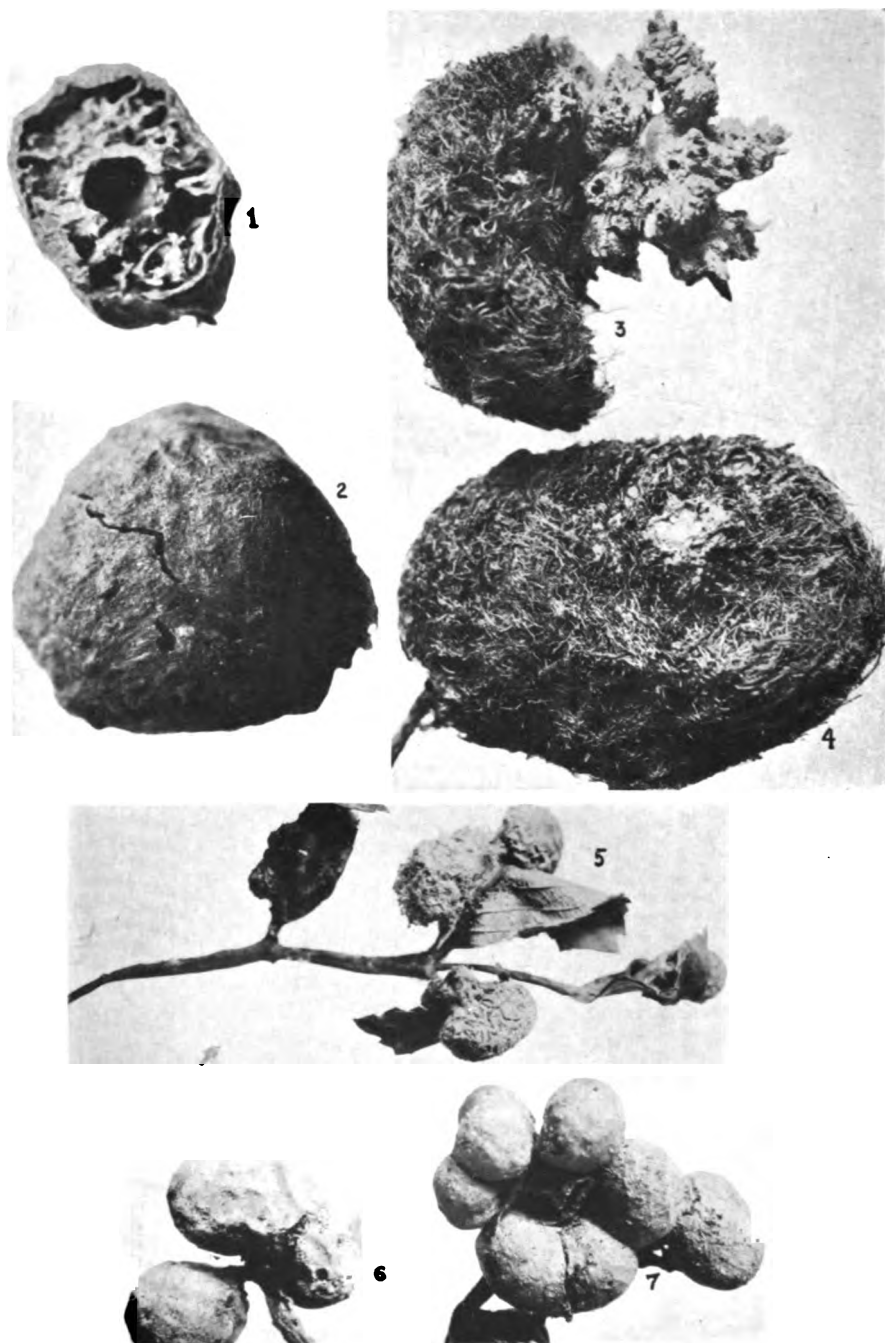


PLATE XXIX

- Figs. 8 and 9. *Neuroterus batatus* form *bisexualis* × 1.
Figs. 10 to 13. *Neuroterus batatus* form *batatus* × 1.
Figs. 14 to 16. *Neuroterus noxiosus* form *vernalis* × 1.
Figs. 17 to 19. *Neuroterus noxiosus* form *noxiosus* × 1.

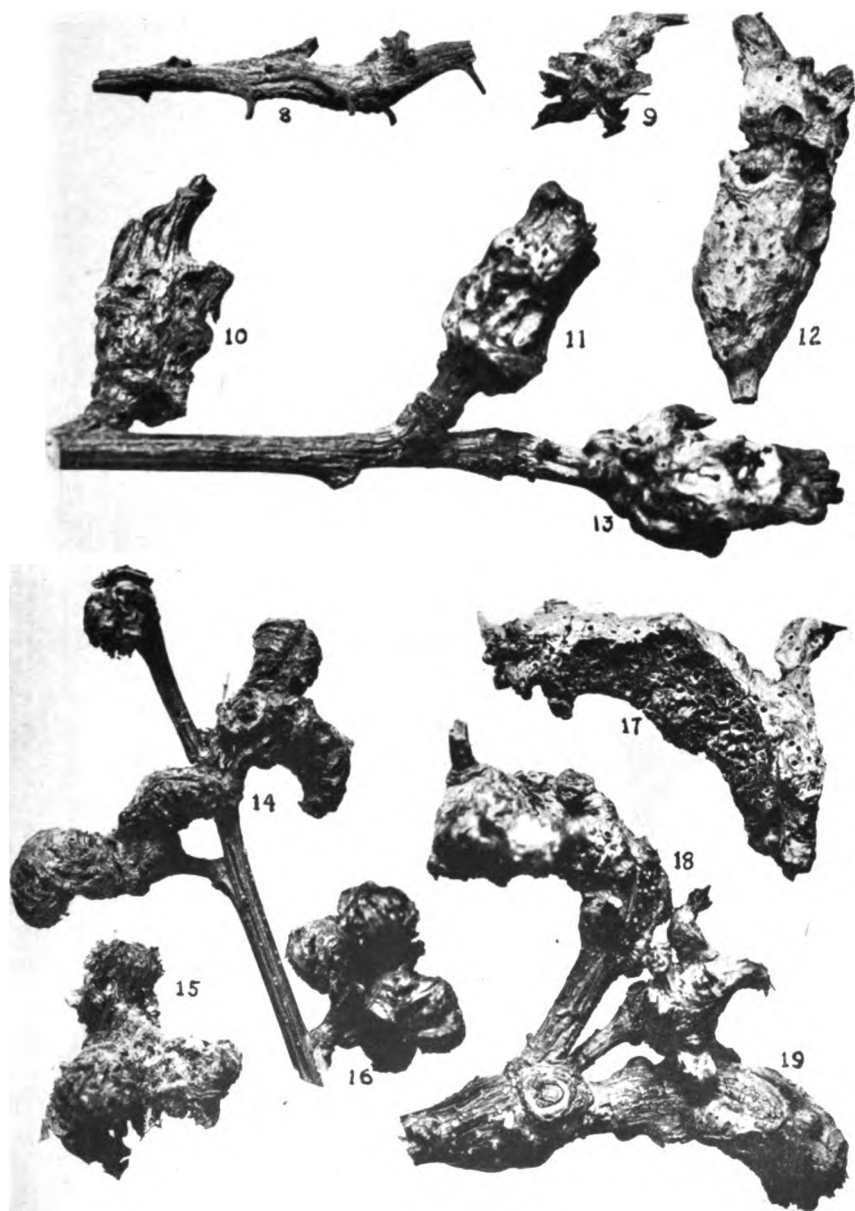


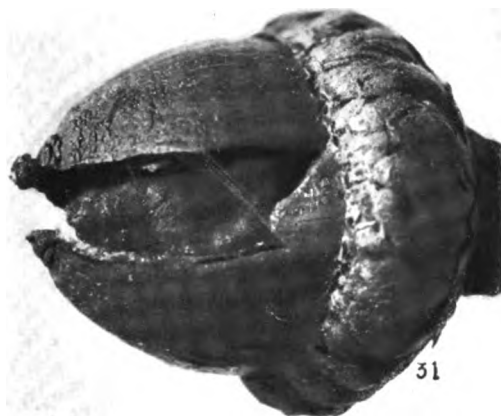
PLATE XXX

- Figs. 20 to 22. *Neuroterus tectus* form *tectus* $\times 3.5$.
Figs. 23 and 24. *Andricus palustris* form *palustris* $\times 2.5$.
Figs. 25 and 26. *Andricus palustris* form *compressus* $\times 2.5$.
Fig. 27. *Andricus futilis* form *radicicola* $\times 4$.
Figs. 28 and 29. *Andricus futilis* form *futilis* $\times 4$.



PLATE XXXI.

- Figs. 30 and 31. *Andricus operator* form *operatola* ×4.
Fig. 32. *Andricus operator* form *operator* ×2.
Fig. 33. *Andricus fulvicollis* form *bicolens* ×4.
Fig. 34. *Andricus fulvicollis* form *erinacei* ×4.



Article VII.—PHYLOGENY OF CYNIPID GENERA AND BIOLOGICAL CHARACTERISTICS¹

BY ALFRED C. KINSEY

PLATE XXXII

CONTENTS

	PAGE
INTRODUCTION.....	357a
DATA CONCERNING EVOLUTION.....	357b
Radial Cell.....	357c
Radial Vein.....	358
Second Abdominal Segment.....	360
Host Plants.....	361
Gall Structure.....	365
Reproduction.....	369
Alternation of Generations.....	372
Other Considerations.....	382
PHYLOGENETIC POSITION OF GENERA.....	385
Aulacini.....	385
<i>Aulacidea</i>	385
<i>Phanacis</i>	387
<i>Timaspis</i>	387
<i>Aylax</i>	387
<i>Diastrophus</i>	389
<i>Gonaspis</i>	391
Rhoditini.....	391
<i>Rhodites</i>	391
Cynipini.....	394
<i>Neuroterus</i>	394
<i>Disholcaspis</i>	397
SUMMARY.....	399
BIBLIOGRAPHY.....	402

INTRODUCTION

Up to the present time the relationships of the genera or even species of the Cynipidæ (Hymenoptera) have been poorly understood. Species have been catalogued without much attempt to discover an arrangement which would indicate evolution, and the genera have been in large part unnatural groups containing large numbers of unassorted, diverse organisms. Moreover, few suggestions have hitherto been made as to the origins of the peculiar biologic phenomena so character-

¹Contribution from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 165.

istic of the more specialized gall-wasps. Information as to the evolution of some of these phenomena is highly desirable and nothing of the biological characters of such specialized creatures can be adequately learned except as it is studied in connection with the morphological characters, careful taxonomic work, and observations of the living insects.

The data here assembled is the result of a study of the Cynipidæ of the world, actual specimens of almost ninety per cent of which have been examined. Much information has been gained by a study of living material. The conclusions reached, as yet only incompletely applied to the genera of the family, will serve as the basis for a thorough revision of the classification of the Cynipidæ which I hope to be able to publish soon.

I am under great obligation to the same friends who have aided my other studies of the gall-wasps: Dr. Wm. M. Wheeler, Prof. C. T. Brues, and Prof. Irving W. Bailey of the Bussey Institution of Harvard University; Nathan Banks of the Museum of Comparative Zoology; Charles W. Johnson of the Boston Society of Natural History; and Dr. Frank E. Lutz of The American Museum of Natural History.

DATA CONCERNING EVOLUTION

RADIAL CELL

(Table I)

The wing venation of the Cynipidæ is remarkably uniform throughout the whole range of species. Only the genus *Eschatocerus*, with one known species, shows any considerable modification from the type; in that species the first and second cubital cells are closed by the extreme reduction of the second abscissa of the radius and of the second cross-vein. The related Figitidæ show a wide range of variation from the complete cynipoid venation to a condition almost as specialized as that found in those Chalcididæ which have retained only a single vein. In the Cynipidæ the modifications are very slight, and these, e. g., the presence or absence of the areolet, the extent of the cubital vein in particular, the extent and continuity of other veins, and the angles of the veins, are characters mainly of specific or even individual worth, sometimes differing on the two sides of the same specimen.

Nevertheless, it is possible to perceive two lines of modification of the venation which seem to indicate something of group relationships: (1) the radial cell, varying from a completely closed to a wide open condition, and (2) the first abscissa of the radius, varying from an arcuate to an angulate condition.

It may be considered that the open radial cell is more highly specialized than the closed cell, for the process of opening in this instance involves the disappearance of the marginal vein and later of the extremities of the subcostal and radial veins. It would be surprising to find that species with the open radial cell had developed the veins necessary to close the cell and thus originated the closed-cell forms. Evidence of evolution based on a consideration of this point alone would be meager enough, but if it parallels the data of other sorts it will lend that much more weight to the final conclusions, and at a couple of points it will bridge gaps in the history.

From the table it will be seen that the character of the radial cell is of generic importance. Although it is true that *Aulacidea* is separated from *Aylax* primarily upon this character and that this is the best reason for considering *Aulacidea* a distinct group from and more primitive than *Aylax*, nevertheless, in many other instances where the genera are founded upon other morphological characters, it will be seen that the condition of the radial cell is as good a generic character. Thus, for instance, *Disholcaspis* is a genus founded on peculiarities of thoracic sculpture, the size and shape of the second abdominal plate, and the shape and proportions of parts of the head, among other very definite characteristics. The occurrence of the open radial cell in all the known species of that genus suggests that the genus as a unit is descended, rather indirectly, from a group with the closed cell. On the other hand, in *Rhodites*, a genus maintained likewise on abundant, definite morphological and biological characters, although thirty of the species have the cell entirely closed, six species have the cell more or less open. It seems probable that in this instance the group has originated directly from a closed-cell genus, and that comparatively recent evolution within *Rhodites* itself has given rise to the few species which possess the open cell.

The order in the accompanying table is that of the apparent order of evolution, as indicated by this sort of evidence only. Again, I acknowledge the meager value of these considerations, except they be judged in connection with the other sorts of data present in this paper.

TABLE I. RADIAL CELL

Genus	No. of Species	Nature of Radial Cell
<i>Ceroptres</i>	± 16	Entirely closed
<i>Synergus</i>	± 60	" "
<i>Perichistus</i>	± 10	" "
<i>Aulacidea</i>	22	" "
<i>Phanacis</i>	2	" "
<i>Timaspiæ</i>	7	Closed in 1 sp. Partly closed in 1 sp. Entirely open in 5 sp.
<i>Diastrophus</i>	14	Closed in 1 sp. Open in 13 sp.
<i>Rhodites</i>	36	Closed in 30 sp. Open in 6 sp.
<i>Aylax</i>	26	Entirely open.
<i>Neuroterus</i>	54	$\pm$ closed in 6 sp. Open in 48 sp.
<i>Cynips</i> (in European sense)		Entirely open.
<i>Disholcaspis</i>	27	" "
<i>Amphibolips</i>	25	" "
All other Cynipini		Open, usually entirely open.

RADIAL VEIN

Plate XXXII

The first abscissa of the radial vein of the wings of the Cynipidæ varies from an arcuate to a sharply angulate condition, some species showing a pronounced, vein-like projection into the radial cell at the apex of the angle made by the vein. Every degree of gradation between the extreme forms may be found. Indeed, so remarkably complete is the list of transitional forms that it was this exhibition which first drew my attention to the existence of evidence of the course of evolution in the group, and I have failed to find any other one line of data which offers as complete a story as that presented by these gradations in vein form. A sufficient display of this variation is shown in the wings of the forty-five species which I figure to remove any necessity for an account of the details of conditions in particular species.

It is to be remarked that no great variation in the vein is to be found among the species of a single genus, i. e., the form of the vein is a generic character, indicating the same lines of generic limits which were drawn originally after considerations of very diverse morphological characters. In the Figitidæ, in *Aulacidea*, *Aylax*, *Neuroterus*, *Disholcaspis*, *Cynips* (of European authors), and in *Amphibolips* every species which I have seen agrees in details of venation with a pattern typical for its genus.

But in *Diastrophus* and *Rhodites* we find both an arcuate and an angulate condition occurring in the same genus, though the differences between two species at the extremes of variation within the genus are not to be compared with the extreme differences which occur between the genera. Apparently the form of the first abscissa of the radius gives evidence not only of group descent but also of the evolution of the species within a genus. Such a complete set of data, interpreted in the light of other evidence, should prove of great value for discovering an arrangement of the species of the family which will indicate the natural order of relationships.

The problem with which we are now confronted is to discover where in the series was the starting point, the primitive condition—of deciding in which direction development has proceeded. If, in trying to solve this question, we seek evidence in the related families of Hymenoptera, we find that apparently very little help is to be obtained there. In the Figitidæ, which are mainly parasitic species, every species of the hundreds I have examined shows an arcuate vein, which is one of the extremes to be found in the Cynipidæ. Shall we assume that the gall-wasps have originated from the more primitive figitids or that the figitids have originated from the most highly specialized of the cynipids? I think that the story might be read with equal justice in either direction if the whole of our information came from the wing-venation. In the arcuate vein we might picture the remnants of two veins of an ancestral, a more primitive, a more abundant vein condition, the two veins still evident and not entirely fused in those species showing an angulate vein. On the contrary, it is reasonable to believe that the angulate vein is the more developed condition: if this is truly the radial vein, it is a longitudinal vein and the projection at the apex of the angle is a cross-vein even though it extends lengthwise of the wing. The addition of such cross-veins to a primitive venation is not an unknown thing, though we have not realized that such additions occur very often among the Hymenoptera. Moreover, we have no great warrant in believing that this projection on the radial vein is really a vein; it is not to be distinguished from chitinizations which occur in the wings of many other Hymenoptera, and I cannot see good reasons for believing that the projection in this case is to be considered a vein rather than some other sort of formation.

It is to be expected that, where such limited considerations are drawn upon, the interpretations may be made in diametrically opposite fashions and we need not be impressed with either set of interpretations

until one of them is supported by other sorts of evidence. The important fact is that the vein considered does clearly show a path which was taken in the evolution of the insects. That the path itself does not indicate in which direction the journey was made is no reason for ignoring the existence of the path. Other signs beside the road will supply proof enough of the direction of the movement along that road.

To anticipate the conclusions which will be drawn later, it may be said that all other considerations, without an exception, point to those insects which have the arcuate vein as being most primitive; those having the angulate vein are by all means the most specialized of the gall-wasps; and an arrangement of the groups of intermediate grades of specialization strictly parallels an arrangement of those groups on the basis of venation only. Such strict parallelism of the indications of evolution of the groups demands parallel interpretations of the direction in which the evolution has progressed. It seems that we must believe that the angulate first abscissa of the radial vein in the wings of the cynipoids has developed by gradual transitions from an arcuate vein.

SECOND ABDOMINAL SEGMENT

An enlarged abdominal plate may be the result of the fusion of two or more plates or the actual increase in size of that plate in the course of evolution. The primitive condition, somewhere in the more or less remote ancestry of any group of insects, showed the segments more or less equal in development, and any condition which shows a single segment especially developed is undoubtedly the result of later evolution. Whether the degeneration of a segment that has become thus specialized ever occurs is a question to be debated for each group studied.

The dorsal plate of the second segment of the abdomen of Cynipidæ is always more developed than any of the other dorsal plates and in many instances the plate has become so enlarged as to cover almost the entire abdomen. That this enlargement in the true gall-wasps is not the result of fusion is evidenced by the continued existence of the other plates underneath the enlarged plate. A study of the character of the segment among all of the gall-wasps shows it to have, very apparently, generic significance, and this has been recognized in the foundation of many of the genera. In the *Andricus-Cynips* group of wasps the stricter use of this character will help solve the true relationships.

A study of the figures on Plate XXXII will illustrate the following. In the cynipoid genus *Ibalia* the second dorsal plate does not show any special modification, the segmentation appearing of a more primitive

sort except for the great development of the sixth segment, a line of evolution not pursued elsewhere among the Cynipoidea. The genus *Aulacidea* has the second segment less developed than in any of the other genera, a fossil species showing the plate still smaller. *Timaspiis* and *Aylax* show conditions intermediate to *Diastrophus*, where the segment covers about one-half of the abdomen. In *Rhodites* the segment is larger than anywhere outside the group of the oak gall-wasps, and in this genus the peculiar production of the hypopygium also indicates an advanced degree of evolution. Of the oak gall-wasps, *Neuroterus* shows the most primitive second segment. In some of the species called "*Andricus*" the specialization reaches its extreme.

These and other instances are of a sort which invites interpreting the less developed segment as the most primitive. And such an interpretation agrees with the information concerning evolution furnished by other lines of evidence. But, in *Amphibolips*, *Disholcaspis*, and possibly some other groups which are clearly highly specialized in many respects, it is surprising to find the segment not as greatly developed as among some less highly specialized oak gall-wasps. It is possible that a degeneration of the plate has occurred in these instances, but it is also likely that there were several lines of evolution among the oak gall-wasps, along one of which the second segment did not develop as far as along another, even though other characteristics evolved farther in the first instance.

HOST PLANTS OF THE CYNIPIDÆ

(Table II)

About 86 per cent of the known species of gall-wasps produce galls on species of *Quercus* and are confined strictly to that single genus of plants. Another 7 per cent are confined to species of the genus *Rosa*. The remaining 7 per cent are found on plants of thirty-five different genera, ranging all the way from the monocotyledons to the highest composites. That is, the hosts of a very small percentage of the species are distributed very widely throughout the flowering plants, while 93 per cent are restricted to plants of only two genera.

It is hard to understand how this extreme specialization has come about. That the oak has advantages as a shelter for an insect is readily seen, but it belongs to a comparatively small family of plants, the genus has only a limited distribution over the world today, and, whatever the qualifications of the oaks, it is not apparent why other plants should be so completely abandoned. That these other plants are capable enough

of producing galls is evident, for other gall insects of other families produce galls upon them in abundance. But, though we cannot understand the reasons for such a condition, the fact remains that there is this great specialization in the choice of host.

It need hardly be argued that this specialization has very likely been the more recent development in the evolution of the Cynipidæ. It is not unreasonable to believe that the primitive gall-wasps inhabited a wide range of plants and that these polyphagous forms have become relatively few as the numbers of the more specialized species increased. That the small percentage of the insects which are polyphagous today, which still possess the more primitive habit, are to be considered actual remnants of the ancient forms, can be readily shown.

In the accompanying table, which shows the number of species of Cynipidæ known to occur on each of the genera of host plants, the insects are listed by tribes. These tribes are well-defined groups, characterized primarily by distinct morphological structures, especially of wing-venation and of the abdomen, and the close relationship of the species included in each of the tribes is as certain as may be desired. Now, it is conspicuous that specialization in the choice of hosts is restricted to the species of particular tribes, and that practically every species in those tribes has adopted the special host. All but one of the species of the Cynipini are found regularly on oaks and all of the species of Rhoditini are found as regularly on roses, though rarely one or two of the species of each group will produce galls on a second plant as well as upon their own hosts. Finally, it is to be seen that all of the species which inhabit the plants of the many genera belong to the one tribe Aulacini. It is evident that the specialized host was not adopted by species of the Cynipidæ severally and at different times, but at two distinct periods, by two groups of forms, at a time about coincident with the differentiation of the tribes which those two groups now constitute. And it is as clear that the Aulacini comprise forms most like the primitive polyphagous species from which the Cynipini and Rhoditini have arisen at different times.

In confirmation of this, it is significant to find that not only are the Aulacini, as a group, polyphagous but that several of the species of the group are, individually, polyphagous. These are the only species of all the gall-wasps which are known to be regularly found on plants of different genera, though most of the cynipids will produce galls on several species of plants of the same genus. *Aylax pisum* lives in galls on *Lygodesmia* and on *Stephanotis*; *Aulacidea tumida* is found on *Solidago*,

Sonchus, and *Lactuca*; while *Aylax hieracii* is found not only on species of *Hieracium*, *Linaria*, and *Cytisus*, but also possibly in the galls on *Triticum*.

Within the Aulacini of today, however, some degree of specialization may be noted. Over a third of all the species of the tribe are confined to plants of the rosaceous genera *Potentilla*, *Fragaria*, and *Rubus*; thirteen of these species, i. e., all but four of those found on those plants, belong to the very distinct genus *Diastrophus*, and this comprises the whole of the genus as far as known. Here again is specialization developed as the group has become morphologically distinct, but in this case the choice of hosts has not reached the extreme of specialization, nor has the morphological differentiation become more than generic from the parent forms of Aulacini.

The only other apparent case of specialized hosts in the Aulacini is in the choice of many genera of the Compositæ; but there is little significance in this fact, for the Compositæ are so predominant among plants today, both in number of species and of individuals, especially among woody-stemmed plants which offer winter shelter to insects, that a due representation of the genera of this family would always have a dominance of numbers. Moreover, there is no restriction of any one or two of the genera of the Compositæ to any single genus of the Aulacini except in instances where the number of species concerned is too small to warrant conclusions.

This immediate data, considered independently, would indicate that the following arrangement shows the order of origin of the cynipid genera:

PRIMITIVE	INCIPIENTLY SPECIALIZED	HIGHLY SPECIALIZED
Aulacini (excluding <i>Diastrophus</i>)	<i>Diastrophus</i>	Rhoditini Cynipini

TABLE II. HOSTS OF THE CYNIPIDÆ

Cynipid	Host Plant	Known No. of Species of Cynipidæ	
		Of the World	American
Eschatocerini	Leguminosæ		
	<i>Acacia</i>	1	1
Pediaspidini	Aceraceæ		
	<i>Acer</i>	1	
Aulacini	Gramineæ		
	<i>Triticum</i>	1	
	Liliaceæ		
	<i>Smilax</i>	1	
	Papaveraceæ		
	<i>Papaver</i>	3	
	Rosaceæ		
	<i>Fragaria</i>		1
	<i>Potentilla</i>	7	8 (or 4?)
	<i>Rubus</i>	9	6
	Leguminosæ		
	<i>Cytisus</i>	1	
	Asclepiadaceæ		
	<i>Stephanotis</i>	1	
	Labiataæ		
	<i>Nepeta</i>	3	1
	<i>Phlomis</i>	1	
	<i>Salvia</i>	1	
	Scrophulariaceæ		
	<i>Linaria</i>	1	
	Valerianaceæ		
	<i>Valerianella</i>	1	
	Compositæ		
	<i>Solidago</i>	1 (?)	1 (?)
	<i>Bigelovia</i>		1
	<i>Silphium</i>	4	4
	<i>Ambrosia</i>	1	1
	<i>Serratula</i>	1	
	<i>Centaurea</i>	6	
	<i>Hypochoeris</i>	2	
	<i>Urospermum</i>	1	
	<i>Picris</i>	1	
	<i>Tragopogon</i>	2	
	<i>Scorzonera</i>	1	
	<i>Taraxacum</i>	1	1
	<i>Sonchus</i>	2	1
	<i>Lactuca</i>	5	3
	<i>Lygodesmia</i>	1	1
	<i>Crepis</i>	1	
	<i>Prenanthes</i>	1	1

TABLE II. (continued)

Cynipid	Host Plant	Known No. of Species of Cynipidæ	
		Of the World	American
Rhoditini	<i>Hieracium</i>	1	
	Rosaceæ		
	<i>Rubus</i>	1 (?)	2 (?)
	<i>Rosa</i>	31 = 6.0%	30 = 7.0%
Cynipini	Fagaceæ		
	<i>Fagus</i>	1 (?)	
	<i>Castanopsis</i>		1
	<i>Quercus</i>	436 = 84.8%	370 = 86.5%

The first set of figures is based on Dalla Torre and Kieffer's catalogue (1910) of the Cynipidæ of the world, the second set on my own catalogue of the American Cynipidæ. My catalogue includes a wider recognition of synonyms and is brought more nearly up to date than Kieffer's. I have omitted two "species" of the Cynipini—*Rhoophilus loewi* Mayr, which is evidently an inquiline in the *Rhus* gall, and *Solenozopheria vaccinii* Ashmead, which I have reason to believe is not the true maker of the huckleberry gall with which the single specimen was taken.

GALL STRUCTURE

(Table III)

Of all plant deformations, the galls inhabited by the gall-wasps show the most astonishing of elaborate and regular designs, and many theories have been invented to explain what may be the causes of such phenomena. Apparently the secret is still far from solution. I have nothing at this time to contribute on the subject, nor is it in point here to review the work of those who have tried to solve the question. What may be offered now is material to show that all of this elaborate organization of plant tissue has arisen within the history of the Cynipidæ alone, independent of any other group of gall-making insects, since a day when the family was merely plant-tissue-inhabiting, not yet gall-producing.

That the factors responsible for the form of the deformation are specific for the insect inhabiting the gall has always been recognized. The number of designs of these galls is about as great as the number of species of insects producing them. Occasionally two apparently different species of wasps will produce galls very nearly identical,¹ but a careful

¹For examples, *Andricus singularis* and *A. osten-sackeni*; *Amphibolips citrifolia*, *A. coelebs*, and *A. ilicifolia*; *Neuroterus batatus* and *N. noxiosus*; *Disholcaspis cinerea* and *D. unicolor*; *Philonix pesomachoides* and *P. hirta*, are among the few cases of close identity of galls.

study of even these instances will show that there are constant enough differences between the galls of the species. On the contrary, a few instances might be cited where the same insect is found inhabiting galls so different in form that they have been considered as distinct species. In these cases it seems that the influences of the host plant organization have come to the front, for where two galls are thus dissimilar they are found always upon host plants of different species. Thus the smooth form of the gall of *Rhodites dichlocerus* is found on species of rose whose stems are comparatively unarmed, and the very spiny form of the gall, produced by the same species, is found upon species of rose whose stems are normally more densely covered with prickles. But such cases are the exceptions. It is only rarely that the importance of the plant in determining the character of the gall becomes more than secondary; the specific qualities of the insect inhabitant are the primary factors in determining the form of the gall.

The factors inciting gall formation have more than this specific nature. They show qualities which are generic for the insect producing the gall, but not for the host plant on which the gall occurs. This fact has been vaguely recognized by students of cynipid galls for many years. It has been natural to refer to a "typical *Disholcaspis*" or a "typical *Amphibolips*" gall, but such statements have never been carried to the point of defining the characters of the galls of any of the genera of the Cynipidæ. After an elaborate study of the histology of galls of many species, Melvin T. Cook (1902) arrived at the conclusion that "The morphological character of the gall depends upon the genus of the insect producing it rather than upon the plant on which it is produced, i. e. galls produced by insects of a particular genus show great similarity of structure even though on plants widely separated; while galls on a particular genus of plants and produced by insects of different genera show great differences." This bore out the experience of all who had carefully examined galls. It was valuable to have the confirmation of an histological study, but an examination of the gross morphology of the structures offers as satisfactory information, and there seems to be no reason why it is necessary to study the microscopic structure of the gall before one can perceive its generic characters.

With such brilliant guides available to indicate generic relations of the insects, it is surprising that no student has employed gall characters on any large scale in classifying the Cynipidæ. Strange inconsistencies are found in our present-day classifications which have arisen because the generic characters of the insect were not sufficiently apparent, al-

though the characters of the gall might have thrown considerable light on the question. In revising the genera of the Cynipidæ, I shall give great consideration to lines that the gall characters may indicate, then, of course, looking for confirmation of these by the less evident characters of the insect morphology.

The galls of each genus are not only of the form typical for the group, but also of a degree of complexity which is usually quite uniform within the group, with considerable variation between groups. The galls of species of a wide range of genera studied by Melvin T. Cook (1902-4), Cosens (1912), and others all show a similar differentiation of the plant tissue into three zones, the epidermal, the parenchymal, and the nutritive, with often the addition of a fourth zone, the protective. But, although all cynipid galls are formed on fundamentally the same pattern, the developments of that pattern are surely much more complex in certain cases than in others. It seems proper to call those galls most simple in which the extent of proliferation of the plant tissues is least in amount (relative to the amount in that part of the plant normally), where the separation of the zones of tissues is least definite, and where the gall is still an integral part of the host plant; and to call those galls more complex where the amount of new tissues is relatively greatest and the separation of the zones is most complete, resulting in the complete independence of some of the zones in some cases (especially in the production of a separable larval cell) and where the separation of the gall from the host is most complete, the gall in many cases becoming almost or entirely a separable organism, connected with a food supply by only a small amount of tissue or in some cases actually developing in size and in formation of new tissue after the gall has left the parent plant. Involved with these characters of complexity will also be a reduced number of cells or a single larval cell within each gall; the smaller the number of larval cells in a single gall, the greater the amount, relatively, of new tissues produced by each individual insect, and the more definite the gall structure; consequently the monothalamous gall indicates greater specilization than either the polythalamous or the agglomerate gall.

In accordance with our understanding that the galls of each genus of gall-wasps show related characters, we find (as detailed in the accompanying table) that the degree of complexity of gall structure shows the generic relations of the insects producing the galls. It is to be noted that in many of the genera the galls are all of a single degree of complexity. Without an exception, the galls of *Aulacidea* are of about one degree of

simplicity, of *Disholcaspis* of one degree and sort of complexity, of *Amphibolips* of another, etc. The absolute uniformity in these genera of the degree of complexity needs to be fully realized, for it has some significance. In several genera, *Rhodites*, *Neuroterus*, etc., there is a range, more or less wide, in the degree of complexity of the galls of a single genus and, with our present inadequate knowledge, we cannot be sure what this may mean; but such instances do not invalidate the force of the fact that in many cases the degree of complexity of gall structure is a definite indicator of the generic nature of the insect.

If the gall (however it may be produced) is an expression of the physiological make-up of the insect; if the form of the gall is an expression of both the specific and generic constitution of the insect; if the degree of complexity of the gall is a definite guide to the generic nature of the insect; then we may believe that the degree of complexity of gall structure is an expression of the degree of development, evolutionarily, of the insect. Specific and generic characters are merely expressions of the relationships of the origin, in the course of evolution, of the organism; and anything which is constantly an expression of these generic qualities (as the gall structure and degree of complexity undoubtedly are) will indicate these evolutionary relationships. This is my justification for believing that the simplest galls are found among the most primitive Cynipidæ, and that the most complex galls are found only among the highest Cynipidæ. We must admit that there seems to be nothing known that demands that only the highest cynipids produce complex galls, but this ignorance is due, patently, to the fact that we know nothing of the way in which galls are produced. All we can say is that some activity on the part of the insect is responsible for the gall production, and it is in no wise unreasonable to think of that activity becoming more potent in its effect as the insect has evolved.

In the accompanying table of the gall characters of certain groups of Cynipidæ the genera have been arranged in the order of an increasing degree of complexity of the gall, and we believe that order to be in some degree the order of origin of the genera, making due allowances for the inadequacies of a linear arrangement of an evolutionary series. We may allow details of relationships to be worked out by other lines of evidence, but we should attach some importance to the very primitive character of all the galls of *Aulacidea* (without a single exception), to the less primitive but still simple qualities of the galls of *Aylax*, *Diastrophus*, and *Neuroterus*, and to the highly developed characters of the galls of *Cynips* (European sense), of *Disholcaspis*, and of *Amphibolips*.

TABLE III. CYNIPID GALLS

Genus	Amount of Hypertrophy	Larval Cell	Order of Larval Cells	Connection with Host
<i>Aulacidea</i> <i>Phanacis</i> <i>Timaspis</i> <i>Aylax</i>	None, or small	Not distinct nor separable	Agglomerate	Not distinct, and entirely inseparable
	None, or small, or great	Distinct but inseparable	Agglomerate or polythalamous; monothalamous in 4 species	Not distinct, or not separable; separable in 3 or 4 species
<i>Rhodites</i>	Small or great	Distinct but inseparable	Agglomerate or polythalamous	Inseparable or separable
<i>Diastrophus</i>	Small	Distinct, but only slightly separable	Agglomerate or polythalamous	Inseparable
<i>Gonaspis</i>	Not very great	Distinct, only slightly attached	Monothalamous	Separable
<i>Neuroterus</i>	None, or small	More or less distinct; not separable	26 species agglomerate or polythalamous; 26 species monothalamous	30 species inseparable; 22 species separable
<i>Amphibolips</i>	Great	Very distinct, but more or less connected with the rest of the gall by strands of fibers.	Monothalamous	Entirely distinct and separable
<i>Disholcaspis</i>	Great	Entirely distinct and separable (at least in maturity)	Monothalamous	Entirely distinct and separable

REPRODUCTION

(Table IV)

A large proportion of the Cynipidæ reproduce agamically. There can be little question of the non-existence of the males of many of the species. Hartig (1840) bred almost 10,000 individuals of a single species, *Dryophanta disticha*, and secured only females. In spite of extensive collecting and breeding of many species of gall-wasps, both in Europe and America, no males have been found for some of them, and Adler (1881) and other workers have regularly secured galls and mature insects from the eggs of these agamic females.

The successive generations of some species are all similar and agamic; Adler found this to be the case with five species, each of which he bred for two successive generations—for three generations in the case of *Andricus seminationis*. In the case of other species, most likely for the

majority of the oak-gall-producing Cynipidæ, only the alternate generations are similar, every agamic generation being succeeded by a bisexual generation, which in turn produces an agamic generation. Where this heterogeny occurs the origin and development of an agamic generation has been so involved with the origin and development of the alternation of dissimilar generations that the problem is more properly discussed in the section of this paper on the alternation of generations. The simpler case, where only agamic generations exist, will be discussed here.

That agamy is a more specialized method of reproduction than a bisexual method need hardly be argued. The evolution of agamy among the Cynipidæ is easily understood, for among the species still existing to-day we find all gradations from the primitive bisexual to the specialized agamic condition. Among the species of *Aulacidea*, the sexes are produced in about equal numbers and normal sexual reproduction occurs. Here and in the very closely related genera are the only instances of normal sexual reproduction found in the whole family, except such as occur in the sexual generation of heterogenous species. In *Diastrophus* the male sex is much less abundant than the female, constituting only about thirty per cent of the total number of individuals, and it is therefore very likely that parthenogenetic reproduction occurs frequently in the group. But that the eggs are still often fertilized is quite certain; I have many times seen copulation in the case of *Diastrophus nebulosus*. In *Rhodites*, however, it is definitely known that for several species the parthenogenetically produced eggs are the regular means of reproduction, and Adler (1881, p. 153) went so far as to call the males of these species superfluous. Though it is still likely that the males do occasionally fertilize the females in these species, it is quite certain that, as Adler put it, "we can predict that they [the males] will probably become extinct in the course of time." In *Disholcaspis* we have instances where apparently only females are ever produced, but it is still possible that there is a bisexual, an alternate generation yet to be discovered among those species. At any rate complete agamy has been attained by at least those five species of *Andricus* studied by Adler.

The accompanying table giving some data as to the ratio of the males to females is based on my own observations, supplemented in a few cases by records from other observers. The total amount of the data is very meager, but is enough to indicate what are undoubtedly the true conditions among several of the groups. The order of the species is that of the diminishing abundance of the males. This is largely a generic arrangement of the species, which indicates that the sequence

is to some extent evolutionary, but it should be emphasized that, though a strictly agamic group is in that respect more specialized than one only partially agamic, it need not necessarily be derived from the next less strictly agamic group. Thus, though *Diastrophus* is undoubtedly derived from *Aulacidea* or related forms, as indicated by the consideration of reproduction in the group and as confirmed by several other sorts of evidence, and though *Rhodites* is undoubtedly a more highly specialized group than *Diastrophus*, it is not to be believed that *Rhodites* originated from *Diastrophus*. Other considerations indicate distinct origins of *Diastrophus* and of *Rhodites* from *Aulacidea*, rather directly in each case. That is, the agamic condition has arisen independently at least three times among the Cynipidæ, not to mention its further occurrence among the forms which have an alternation of generations. And, though we do not have the transitional conditions for each of the lines of development, it seems clear that this agamic condition is the result in each case of the gradual disappearance of the males and the gradual appearance of parthenogenetic reproduction, first as an occasional phenomenon, finally as the regular and only method of reproduction.

This condition is not in the least surprising, for parthenogenesis has undoubtedly arisen independently at very many different times among a great number of the groups of the Hymenoptera.

TABLE IV. SEXES OF GALL-WASPS

Species	Individuals counted	Per cent Males
<i>Aulacidea podagræ</i>	391	55
<i>Aulacidea bicolor</i>	36	44
<i>Aulacidea nabali</i>	300	36
<i>Aulacidea annulata</i>	120	16
<i>Aulacidea tumida</i>	89	30
<i>Diastrophus kincaidi</i>	39 (Gillette '93)	36
<i>Diastrophus nebulosus</i>	192	28
<i>Rhodites ignotus</i>	37	35
<i>Rhodites dichlocerus</i>	66	8
<i>Rhodites rosæ</i>	419	1.5
<i>Rhodites bicolor</i>	14	0
<i>Disholcaspis</i> (whole genus)		0 (?)
<i>Andricus cellularius</i>	30 (Gillette '92)	0
<i>Andricus dasydactyli</i>	118 (Ashmead '96)	0

ALTERNATION OF GENERATIONS

(Table V)

The alternate generations of certain species of gall-wasps show more remarkable differences than do the alternate generations of any other group of animals in which this heterogeny is known to occur. Because of the careful experiments of Adler (1881) and of others, most students of biology are thoroughly familiar with the extreme differences presented by successive generations of these Cynipids. I have given detailed accounts of the life histories of some of our American species in an earlier paper; and a review of this and of Adler's work will show to what the extremes of differences amount. The galls of two successive generations may be produced on different parts of the plant and may present entirely different forms, e. g., the gall of one generation of *Andricus operator* is mainly a large mass of wool on the young stems, leaves, or aments of the oak; the second generation gall is a small, seed-like, naked capsule between the cup and the acorn. The insects of the two generations of some species may be so entirely different as to warrant believing them to belong to different genera, if the relationships of the two forms has not been discovered. In fact, Adler indicated that in practically every instance the two generations had been placed in different genera.

We have been so impressed with these extreme instances of alternation that we have failed to recognize the less remarkable cases; and the origin of the perfected phenomenon of heterogeny has remained a riddle just because we have not paid sufficient attention to these less extreme instances.

An adequate conception of the characters of the adults and of the galls of the species concerned in this discussion can be gained only by an examination of specimens or by a careful study of the papers already referred to, Adler's paper including most of the European and my paper including most of the American species of which the life histories are known, but the accompanying table will summarize the essential characters for each species.

It is remarkable that for several of the species, all of which belong to the genus *Neuroterus* (of genetic significance), the successive generations are very similar. Indeed, the differences between the adults is so slight as to be practically indiscernible. The main difference is physiological, for one generation reproduces agamically and the other by fertilized eggs. The galls of these two forms are likewise exceedingly similar and, although they may appear quite different in most cases, they are still of fundamentally the same type. The differences in those

cases are of a sort that might be explained as due entirely to the differences in the parts of the plant affected. If it is the young, growing shoot which is affected by one generation in mid-June, and the young leaves and undeveloped stems in the buds which are attacked by the next generation early in the following May, the galls (e. g., *Neuroterus batatus* and *N. noxiosus*) may be rather different in appearance but will be of exactly the same type: an irregular swelling of the part affected, the gall quite inseparable and not even distinct from the parent plant, with the same irregular distribution of larval cells, which cells are of the same degree of complexity in the two generations. Such a case amounts to no more than a seasonal dimorphism among the adults, with the differences in the galls due to seasonal factors and, except for the more complex alternation found in others of the Cynipidæ, one would not ordinarily think of such instances as alternations of generations.

Indeed, it is hard to understand how differences in the forms of the galls of successive generations could be often avoided where the two generations of a species are produced in a single year. The part of the plant affected is usually different for each generation, for it must always be a rapidly growing part of the plant which receives the egg. This last fact explains sufficiently why different parts of the plant are attacked by the insects in the different generations. It may be too much to suggest that in all the instances of extreme differences in the successive generations the differences are due primarily to the extreme differences of the parts of the plants affected, for we do not know enough about the factors influencing gall production to compare adequately the effects; but, in the simpler cases mentioned, we feel warranted in ascribing the most of the differences which appear to this difference in the part of the plant affected. It may be possible to secure more definite information on this subject by experimentally breeding and raising the galls.

That the second generation became fixed in the life cycle of each species only after a period of struggle to find a suitable method of obtaining an existence is apparent from observations already made on two species. Adler (1881) described the way in which *Cynips pallida* (also named *Biorhiza terminalis*, and the alternate was called *Biorhiza aptera*) arrives at the successful location of the eggs of the second generation only after unsuccessful attempts to find the suitable place. The bisexual generation is developed in galls on the terminal buds of young shoots, and oviposits usually in the bark of the roots, but also in the buds and leaf petioles. Galls begin development on the buds and petioles but, as far as is known, do not reach maturity. The galls on the roots are

successful in reaching their full development and from these the alternate, the agamic generation, will be produced. A further point of interest with this species is the fact that the adults of the two generations are very similar except in size, in mode of reproduction, and in the condition of the wings: although the agamic females are always wingless and the males of the bisexual generation are winged, the bisexual females either have normal wings or have reduced wings, or are almost wingless. exhibiting in this as in other respects not well fixed and not very great differences between the alternate generations, even though at first sight the differences appear remarkable.

I have found indications of the same sort of incomplete fixation of the habits of a generation in our common American species, *Biorhiza forticornis*. In the well-known form the adults are wingless, agamic, and emerge in December, often during very cold weather when the ground may be covered with snow. These adults are very strongly geotropic, positively, and will run down the tree to the ground, and I have succeeded in observing them oviposit in the roots or at the bases of the trunks of the white oaks. Though I have not succeeded yet in obtaining galls from these eggs, it is quite certain that a root gall does form and that these develop the adults of the bisexual generation. But, about the middle of the March following the winter emergence of the species, I found a second lot of wingless agamic females emerging from the same galls which had given the first lot of agamic adults. The insects of the two lots were not to be distinguished except by a remarkable difference in sensory reaction: these early spring adults were negatively geotropic, as I thoroughly proved by careful experiments. They climbed up the trees and oviposited in the terminal buds. Although the tree grew nicely that spring, no galls developed from these eggs. Whether galls ever develop from eggs laid by these spring forms of agamic females I cannot yet say positively. It may be that here we have another instance of the sort described by Adler for *Cynips pallida*. It is not unlikely that the fixation of the nature of the second generation for some of the species was a matter of repeated trial, and that only after some forms had failed of survival did one form finally remain and become fixed as the alternate generation. We have no way of estimating how many instances of this sort are yet to be discovered, but it is also reasonable to believe that for some species there was little or no amount of trial before a form was found which could survive.

The alternate generations of very many Cynipidæ differ in their manners of reproduction, one generation reproducing agamically, the next from fertilized eggs. It will be generally believed that in such cases the sexual generation is nearer like the original form of the species. It is true that Adler argued to the contrary. He said (1881, p. 155):

(1) Some species are only propagated parthenogenetically.

(2) No species of oak gall-fly is known to propagate itself exclusively in a sexual manner. They are only known to do so alternately with an agamous generation in a generation-cycle.

Therefore it seems to me reasonable to infer that the present agamous form is either itself the original form or, if not exactly identical with it, it is at least very nearly related to it.

But such reasoning is not likely to be followed by many students. As we have shown earlier in this paper, the strictly agamic species of Cynipidæ have been derived from normally bisexual species. If we were to follow Adler's reasoning, we would have to presume a group of strictly agamic Cynipids from which the dimorphic species might have arisen. But the most primitive of these dimorphic gall-wasps, species of the genus *Neuroterus*, show (in characters of radial cell, first abscissa of the radius, second segment of the abdomen, degree of complexity of gall-structure, etc.) closest relationship to the strictly bisexual genus *Aulacidea* rather than to *Diastrophus*, *Rhodites*, or other groups known to be largely agamic. Undoubtedly the bisexual form of dimorphic species is the original form.

The reason for the existence of agamic generations may be the fact that in almost every known case the agamic is the winter generation of the species. The chances of survival of this generation are naturally reduced by the vicissitudes of climatic conditions. The agamic female often appears in mid-winter when the temperature is far below freezing, or at least matures early in the spring when climatic conditions are still unfavorable. If it were necessary that the female of this winter generation meet a male of the species and that the eggs be fertilized before they were capable of developing, the chances of survival would be greatly reduced.

This may be the whole explanation of the origin of the agamic generation in these insects. If it is, the species found in warmer climates, as in southern Europe and northern Africa, and in the southern United States and Mexico, should not have an agamic generation even though there may be an alternation of generations among the species. It is highly desirable that some student experiment in such regions and solve life histories of cynipids of perpetual summer climates.

At any rate, I see no warrant for believing that the origin of the agamic condition in dimorphic species of Cynipidæ has any connection with the origin of the agamy in species, like *Rhodites* sp., which do not have an alternation of generations. If it is true that there are no such evolutionary relationships, then we may believe that the agamic condition arose independently at four different times within the family: at three points discussed in the preceding section of this paper, and in the connection in which we have discussed it here.

To summarize our conclusions concerning the origin of heterogeny among the Cynipidæ, it is suggested that the alternation of different forms of galls and of adults arose gradually, after a struggle for the fixation of the habits of each generation, among the wasps of the genus *Neuroterus* (or among allied groups), due primarily to seasonal, environmental conditions; that this alternation of generations is merely a more or less extreme type of seasonal dimorphism; and that the occurrence of agamy in one generation is mainly a result of seasonal exigencies.

TABLE V. ALTERNATE GENERATIONS

Species	Gall Begins to Develop	Gall	Adult
<i>Neuroterus batatus</i>			
form <i>bisexualis</i>	Early May	Polythalamous swellings, young stem and petioles; inseparable; larval cells hardly distinct	Bisexual
form <i>batatus</i>	Late June	Polythalamous swellings, main stems; inseparable; larval cells hardly distinct	Agamic. Identical with <i>bisexualis</i> , but slightly larger
<i>Neuroterus noxiosus</i>			
form <i>vernalis</i>	Mid-April	Rather globular polythalamous swellings of leaf-buds, leaves, and petioles	Bisexual
form <i>noxiosus</i>	Mid-June	Elongate, polythalamous swellings, main stem	Agamic. Quite identical with <i>vernalis</i> , but slightly larger
<i>Neuroterus baccarum</i>			
form <i>baccarum</i>	Early April	Spherical, somewhat flattened, monothalamous, separable, on aments and young leaves	Bisexual
form <i>lenticularis</i>	Mid-June	Circular, flattened, cone-shaped, monothalamous, separable, on leaves	Agamic. Rather similar to <i>baccarum</i> , differing mainly in coloring
<i>Neuroterus albipes</i>			
form <i>albipes</i>	Mid-March to Early April	Egg-shaped, monothalamous, on edges of leaf	Bisexual. Abdomen pedunculate
form <i>lavisculus</i>	Early June	Flattened button-shaped or shallow cup-shaped, monothalamous, on veins of leaf	Agamic. Abdomen larger, elongate. Minor color differences from <i>albipes</i>
<i>Neuroterus fumipennis</i>			
form <i>tricolor</i>	May	Globular, with scattered hairs, monothalamous, separable, on leaf-blade	Bisexual
form <i>fumipennis</i>	Mid-July	Circular, flattened, slightly emarginate, finely pubescent, monothalamous, separable, on leaf-blade	Agamic. Differs slightly in structure and sculpture; colors peculiarly like those of <i>tricolor</i>
<i>Neuroterus numismalis</i>			
form <i>vesicatrix</i>	March to April	Button-shaped, centrally depressed, covered with silky pubescence; monothalamous, on leaf; inseparable	Bisexual
form <i>numismalis</i>	Late June	Similar to gall of <i>vesicatrix</i> , but separable from leaf	Agamic. Differs in sculpture and slightly in structure

TABLE V. (continued)

Species	Gall Begins to Develop	Gall	Adult
<i>Neuroterus aprilius</i> form <i>aprilinus</i>	July to August	Bud-gall, bud swollen, surrounded by dwarfed leaves; polythalamous	Bisexual
form <i>Schlechtendali</i>	April to May; lives in this gall 1 or 2 years	On stamen; anther somewhat swollen; monothalamous	Agamic. Differs rather considerably in structure, sculpture, and color; smaller
<i>Chilaspis nitida</i> form <i>löwi</i>	August	Seed-like on aments, covered with hairs, monothalamous or polythalamous	Bisexual
form <i>nitida</i>	May to June	Oval, pubescent, monothalamous or polythalamous, on veins, under leaves; separable	Agamic. Differs slightly, in color especially
<i>Fioriella marianii</i> form <i>meunieri</i>	March	Small, bud-like, in axils of leaves or terminal	Bisexual
form <i>marianii</i>	May to June	Larval cells under bark of main stems	Agamic. Similar to <i>meunieri</i> , but four times as large
<i>Cynips pallida</i> form <i>pallida</i> (= <i>Biorhiza terminalis</i>)	Nov. to Jan. (March ?)	Large, polythalamous masses, spherical, on twigs, mostly terminal	Bisexual. Wings lacking or reduced or short in ♀, normal in ♂
form <i>aptera</i>	July	Irregularly oval, in masses, on roots	Agamic. Very similar to <i>pallida</i> , but almost wingless, two times size of <i>pallida</i>
<i>Andricus ramuli</i> form <i>ramuli</i>	April	Small, oval cells in a large, dense, woolly mass, on young leaves or aments; monothalamous	Bisexual
form <i>autumnalis</i>	Early July	Bud-gall, elongate oval, surrounded by bud-scales; monothalamous	Agamic. Differs somewhat in structure, color and sculpture; slightly larger
<i>Andricus radialis</i> form <i>trilineatus</i> (= <i>A. noduli</i>)	April to May	Slight swellings, terminal twigs or petioles; polythalamous	Bisexual
form <i>radialis</i>	Mid-August	Large swellings, potato-like, on roots or lower part of trunk; polythalamous	Agamic. In structure similar to <i>trilineatus</i> , but differs in color, with a length three times that of <i>trilineatus</i>

TABLE V. (continued)

Species	Gall Begins to Develop	Gall	Adult
<i>Andricus collaris</i> form <i>curvator</i>	Early July	Irregularly globular, involving lamina of leaf	Bisexual
form <i>collaris</i>	Late June	Small, conical, appendiculate, in the winter buds	Agamic. Differs mainly in color and sculpture; somewhat larger
<i>Pediaspis aceris</i> form <i>aceris</i>	April	Rounded, on leaves or petiole, monothalamous	Bisexual
form <i>sorbi</i>	Early July	Pea-like, often clustered, on roots of maple; monothalamous or agglomerate	Agamic. Quite different in color, pubescence, form, structure, and sculpture
<i>Cynips folii</i> form <i>taschenbergi</i>	Oct. to March; usually Jan. to Feb.	Elongate, rather oval, velvety; on buds on sides of twigs, or adventitious buds at base of tree; monothalamous	Bisexual
form <i>folii</i> (= <i>C. scutellaris</i>)	Late May to early June	On veins on under surfaces of leaves; large, globular; monothalamous	Agamic. Quite different in sculpture, structure, color, pubescence; quite a little larger
<i>Cynips longiventris</i> form <i>similis</i>	November	In buds on twigs or at base of tree; monothalamous	Bisexual
form <i>longiventris</i>	Mid-May to June	Small, globular, on leaves, underneath, on veins; monothalamous	Agamic. Differs in color, sculpture; a little larger
<i>Cynips divisa</i> form <i>verrucosus</i>	Oct. to Nov.	Small, globular, shot-like; on leaves, underneath, on veins; monothalamous	Bisexual
form <i>divisa</i>	Late May to early June	Long, oval, with a broad, rounded apex; on edges of leaves, or on shoots, or from buds	Agamic. Quite different in color, sculpture, and pubescence; quite a little larger
<i>Andricus futilis</i> form <i>futilis</i>	Late April	Blister-like, in lamina of leaf; polythalamous, larval cells distinct, joined by fine fibres to outer wall of gall	Bisexual
form <i>radicicola</i>	Mid-July	Cavities beneath bark of roots; larval cells distinct but not separable; little new tissue	Agamic. Differs in color, structure, and sculpture; two times size of <i>futilis</i>

TABLE V. (continued)

Species	Gall Begins to Develop	Gall	Adult
<i>Andricus operator</i>			
form <i>operator</i>	April to early May	Small, seed-like cells, covered with long, dense hairs to form a large, woolly mass, on terminal stems, young leaves, or aments	Bisexual
form <i>operator</i>	Late June	Small, nut-like kernel at base of acorn, between cup and nut	Agamic. Different in color, structure and sculpture; larger
<i>Andricus inflator</i>			
form <i>inflator</i>	Late March to April	A swollen bud and shoot, with a foliaceous covering; monothalamous	Bisexual
form <i>globuli</i>	June to July	Globular bud-gall, surrounded by bud-scales; monothalamous	Agamic. Differs considerably in structure, sculpture, pubescence, etc.; larger
<i>Andricus fœcundatrix</i>			
form <i>pilosus</i>	April	Elongate oval, covered with hairs; among anthers of aments; monothalamous	Bisexual
form <i>gemmæ</i>	June	Bud-gall, with many closely imbricated scales; hop-like; monothalamous	Agamic. Differs in sculpture, structure, and color; three times size of <i>pilosus</i>
<i>Andricus testaceipes</i>			
form <i>testaceipes</i>	April to May	Small, simple thickening of midrib of leaf or petiole or of young twigs, 1 or 2 celled	Bisexual
form <i>sieboldi</i>	Aug. to Sept.	Good-sized, conical, ridged; arising from under bark on older twigs; monothalamous	Agamic. Differs in structure, sculpture, color, and pubescence; much larger
<i>Andricus corticis</i>			
form <i>gemmatus</i>	April to May	Small, egg-like or bud-like, on tips of twigs or in leaf-axils	Bisexual
form <i>corticis</i>	Late July to early August	Irregular swellings in bark of roots or of old bark of trunk, containing a clustered mass of distinctly separate larval cells	Agamic. Very distinct from <i>gemmatus</i> in every respect
<i>Andricus callidoma</i>			
form <i>cirratus</i>	April	Oval, bearing tufts of long hair, forming a dense, woolly cluster among the aments	Bisexual

TABLE V. (continued)

Species	Gall Begins to Develop	Gall	Adult
form <i>callidoma</i>	Early June	Spindle-shaped, longitudinally ribbed, slender-stalked, in axil of leaf	Agamic. Differs from <i>cirratus</i> in every respect; three times as large
<i>Andricus thalpighii</i>			
form <i>nudus</i>	April	Elongate, oval, with a depressed apex, entirely glabrous; on male catkins; monothalamous	Bisexual
form <i>malpighii</i>	Early June	Small, spindle-shaped almost sessil, in leaf-axil; monothalamous	Agamic. Differs in every respect; two times as large
<i>Andricus fulvicollis</i>			
form <i>bicolens</i>	Early Nov.	Small, seed-like, polythalamous, in young buds, at apices or on scales	Bisexual, winged
form <i>erinacei</i>	May	Rather large, oval, spiny, on midvein under leaf; polythalamous	Agamic. Wingless; differs in every respect
<i>Andricus palustris</i>			
form <i>palustris</i>	March to April	Globular, hollow, succulent; the larval cell entirely free; on aments, young leaves, petioles, or stems	Bisexual; winged
form <i>compressus</i>	May to June	Small, globular, hollow, without distinct larval cell, on veins of leaf	Agamic. Wingless; differs in every respect
<i>Cynips megaptera</i>			
form <i>megaptera</i> (= <i>Trigonaspis crustalis</i>)	Dec. to Jan.	Rounded, pea- or cherry-like; monothalamous; on lateral buds on twigs	Bisexual. Winged
form <i>renum</i>	June	Small, kidney-shaped, on veins under leaves; monothalamous, separable	Agamic. Wingless; differing in color, sculpture, structure, etc.; about one-half to one-third as large as <i>megaptera</i>

OTHER CONSIDERATIONS

We have been handicapped in discussing the phylogeny of the Cynipidæ by our lack of knowledge of fossils of the group. The only fossil gall-wasps known are three species which I have recently described. All three of these belong to the genus *Aulacidea*, but whether this is significant may not be determined on the basis of such meager data. Nevertheless, it is remarkable that no cynipid galls are described from fossil oaks. The only fossil galls known are quite certainly not cynipid. I am inclined to believe that the family Cynipidæ is of recent origin, possibly not much older than the Oligocene fossil I have described.

Certainly the family has not existed for any long time with the characteristics shown in the present day by the more specialized groups, for it is inconceivable that the insects could have survived for long any struggle for existence while impeded by the specialized habits possessed by most of the species, as the following brief data may show.

The necessity of the larva passing its life within a gall greatly reduces the parent's chance of finding the proper place in which to oviposit. The parent gall-wasps of most species must find a plant of the one genus and possibly of the one or two species of that genus on which alone it can survive. In most species, moreover, the parent must find a particular part of that special host and, failing to arrive at that spot within the very few hours of its adult life, the insect dies without effecting reproduction. Such a failure is not as likely to occur with forms which are less specialized in their choice of host and part of host affected. Insects of this latter sort are found in the genus *Aulacidea*.

Effective as a highly complex gall may prove as a protection to the larval wasp, it has evident disadvantages. It serves as a prison in which the larva is trapped. The larva has become a degenerate, legless, inactive, helpless organism; and, if once its gall defence is broken, the insect is quite at the mercy of the enemy. The defence offered by the gall itself is, I think, largely theoretical, and exists mostly in the minds of superficial observers. The hardest galls, or galls most complicated with hairs, spines, wool, loose larval cells, etc., or galls rich in tannin crystals, etc., are all abundantly parasitized and, indeed, some of the most heavily parasitized galls are those best equipped (theoretically) against enemies (e. g., *Amphibolips confluens* has 95% parasites, *Callirhytis furnessæ* has 50% parasites, *Biorhiza forticornis* has 96% parasites, *Rhodites rosæ* has 15% parasites, etc.). The smallest amounts of parasites usually occur with those species of *Aulacidea* which make the simplest galls.

Again, agamic reproduction has evident advantages but it is inconceivable, from what we know of reproduction among animals, that such a method of propagation, especially where agamy has become the only method, can result in anything less than a loss of vitality and the ultimate extinction of the species. This belief may be due to our inadequate knowledge of biological phenomena, but it is significant that the agamic species of cynipids (e. g., *Rhodites*, *Disholcaspis*, and the genera with an alternation of generations) more often fail to reach maturity than do species of the bisexual groups (*Aulacidea*, *Diastrophus*, etc.). It is a common experience to obtain only a score of adults from hundreds of the oak- or rose-galls, while many hundreds of adults may be secured easily from a score of galls of *Aulacidea*, for instance. The failure of those certain species to reach maturity may be due in part to their higher degree of parasitism, but it is not due entirely to that.

Still another thing which indicates decreased vitality in the oak gall-wasps is the short duration of the adult life of most species. Having observed some thousands of adults of scores of species on trees until the insects died natural deaths, I found that about two days was the average length of life for those species, while many species will die almost instantly after oviposition, even if that is only a few hours after the emergence from the gall.

The adults of most species of cynipids are very weak creatures, fatally injured by the slightest touch or by a sudden change of temperature or of humidity. One of the greatest obstacles in my experimental breeding has been the enormous amount of destruction caused if a rainy or even foggy day occurred at the time of emergence of a lot of adults. Although I kept the insects under cover, at such a time they would not oviposit or even make any attempt to climb over the trees; when the weather would become favorable in a day or two most of the wasps had lost all vitality and soon died without laying eggs.

Still another indication of the reduced vitality of most of these cynipids is the number of adults which reach maturity but then do not succeed in making (chewing) their way through the walls of the gall. It is hard to determine what percentage of adults thus fail, at the last moment, to achieve the goal of their lives, but it is apparently large, for almost any collection of galls, cut open, will show many such individuals in galls which were evidently mature before they were gathered. For instance, from one lot of galls of *Andricus pomiformis* not a single individual was bred, although at least 150 entirely mature adults were found within the galls. Osten Sacken bred only one adult from the type

galls of *Andricus pellucidus*, but from the other seven, monothalamous galls I secured seven mature adults, most of which had eaten their way through the walls of the larval cells but had then died before getting through the thinner walls of the outer gall. I gathered many adults of *Andricus tecturnarum* which had emerged through the hard walls of the galls but had then died before escaping from the coat of tangled hairs which covered the galls. Hundreds of other similar instances might be cited. It is likely that under natural conditions there is less of this sort of mortality than when the gall is gathered into breeding jars, but even this indicates an amount of vitality possessed by the insects which is none too sufficient.

On the contrary, species of *Aulacidea* are very easily bred in numbers and it is a rare thing to find adults left in the galls. The adults of these species will always live for many days. I have just found a female of *Aulacidea annulata* which was soaked in alcohol for half an hour and then glued to a cardboard point; the insect was discovered alive after ten days in a Schmitt box. Such vitality, as far as I have ever seen, is not to be found among the oak gall-wasps.

On the basis of these considerations, the Cynipidæ may be divided into two more or less distinct groups. One group, including mainly oak gall-wasps, has little vitality, possesses a mode of reproduction which would seem to guarantee a continuation of the lowering of vitality, and has a manner of living its larval life which invites a tremendous number of parasites and offers often insurmountable obstacles to the insect's growth to maturity. The other group, mainly *Aulacidea* and the allied genera, has a much larger amount of vitality, a method of reproduction (bisexual) which is fit to maintain the vitality of the group, and a mode of larval life (in simple galls or merely in stems) which offers fewer obstacles to the achievement of maturity. The first group is very apparently over-specialized and must ultimately become extinct. It is not likely that such a group could have furnished the progenitors of the second group, i. e., the Cynipini were not the ancestors of the Aulacini. This latter group possesses the far more successful mode of living and is likely to survive until it too has become specialized to the ultimate, the disastrous degree.

PHYLOGENETIC POSITION OF GENERA

AULACINI**AULACIDEA**

We include *Pseudaulax* Ashmead in this group. The radial cell of the wings in *Pseudaulax* is closed, which is a primitive condition found elsewhere among the true gall-wasps only in the genus *Rhodites* and in some few genera known only from a very few species.

In all the species of *Aulacidea* the first abscissa of the radius is arcuate, one of the extreme forms of that vein in this family and, although, as we have already pointed out, the arcuate is not necessarily a more or a less primitive form than an angulate form of the vein, it is definitely an extreme condition in this family. Because of the way in which all the other lines of evidence read, we consider the arcuate vein most primitive rather than most specialized. In one species, *Aulacidea annulata*, the vein is arcuate with a very slight suggestion of an angle on one side only.

The second segment of the abdomen is smaller here than in any of the other gall-wasps, and this small segment represents a more primitive condition than where the segment is enlarged to cover most of the abdomen, as in most of the genera of the family.

The hypopygium in this genus is less highly specialized than in any of the other cynipids. It has not assumed the peculiar, pointed form found in species of *Rhodites*, nor become narrow and elongate as in most of the oak gall-makers. In *Aulacidea* it is still a broad, ventral plate, very little produced.

The species of this group inhabit plants of thirteen different genera distributed widely from one of the lower monocotyledons, *Triticum*, to the highest plants, composites. This wide range of hosts is a very primitive condition, compared with the complete restriction of the greater number (93%) of the gall-wasps to plants of only two genera, and further study will undoubtedly reveal species of *Aulacidea* on many more plants than they are at present described from. Moreover, the only known instances among the Cynipidæ where the same species regularly inhabits plants of different genera seem to be in this genus and in the very closely related *Aylax*. Thus, *Aulacidea tumida* is found on either *Solidago*, *Sonchus*, or *Lactuca*; several of the American species of *Aulacidea* may be found on either *Lactuca* or *Prenanthes*; and *Aylax pisum* lives on *Lygodesmia* and on *Stephanotis*; while *Aulacidea hieracii* has been reported (possibly not entirely correctly) from *Hieracium*, *Linaria*, *Cytisus*, and *Triticum*. This is a remarkable lack of specialization in the choice of host.

The galls of this genus are by far the simplest known among the *Cynipidæ*. Indeed, several species make absolutely no gall and are merely pith-inhabiting insects. *Aulacidea bicolor* has long been known to be such a species, and I have found, on investigations of dead stems, several other species of the same sort, of which I have already described *A. abdita*. Without a single exception, the galls of this genus are simple, never consisting of more than swellings of stems, agglomerate or polythalamous, without separable or even distinct larval cells, and in no case is the gall separable from the plant. As we have shown in the discussion of galls, such simple galls are primitive and indicate primitive relationships of the insects. Very interesting proof of the simple nature of even the most developed of these *Aulacidea* galls is furnished by the galls of *A. podagræ* and *A. tumida*. In each case the insect may be found in stems which show no traces of galls, although definite deformations of the pith surround the larval cells inside the stem; while, at other times, the same species (I am satisfied as to the identity after examination of large series of the insects) will produce a swelling of the stem, making a more or less conspicuous gall. It may be that the state of the plant at the time the insect's egg is laid in it, or the physiological nature of the particular plant, due to its special environment, determines the extent of the hypertrophy. In either event, it seems that the gall-producing powers of the insect are not developed enough to insure the formation of a gall except under the most favorable circumstances, although other *Cynipidæ*, whenever they produce a gall at all, apparently always produce galls of a uniform pattern and of the same degree of complexity.

This (*Aulacidea* and most likely *Aylax* and other related genera) is the only group of the *Cynipidæ* in which the sexes of most of the species occur in about equal numbers. Our data on this point are quite meager but seem to warrant this conclusion. The reproduction is normal, sexual reproduction, which is certainly more primitive than the partially or strictly agamic reproduction of the rest of the family.

There is apparently no alternation of generations in this genus, such as occurs in most of the oak gall-producing cynipids. Nothing that I know of from observation of the American species would indicate that there is anything but normal reproduction in the group. *Aulacidea nabali* emerges late in May and the galls are mature in September, appearing however a couple of months before that. *A. podagræ* emerges in mid-June, and the galls are good-sized by August. *A. tumida* emerges in early June; *A. annulata* emerges in early June; and the galls must develop on the plants before they have become mature, which date for

Lactuca is late July or early August. In all these instances there does not appear to be time enough for the development of an alternate generation in the same year between the date of emergence of the insect and the appearance of the gall of that species. More positive proof of the absence of an alternate generation is furnished by the work of Adler who secured, experimentally, the successive generations of *Aulacidea hieracii* and reported (1881) that there was no alternation of generations with that species. This absence of heterogeny is an important indicator of the lack of specialization of the group in that respect.

Our knowledge of fossil cynipids covers only three species and, with such limited knowledge, we are not warranted in drawing general conclusions. The three described fossils all belong to this genus *Aulacidea*.

The amount of vitality shown by individuals of this genus is (as I have described on p. 384) decidedly greater than that shown by the majority of cynipids, and this may be an indication of the relation of the group to the primitive, more successful insects rather than to the less vigorous, decidedly unsuccessful, more specialized forms.

We must conclude, then, on consideration of these eight or nine sorts of evidence, that this group is the most primitive in relationships of the existing Cynipidæ.

PHANACIS

We should, undoubtedly, place this genus in as primary a position as *Aulacidea*, since the insect is morphologically as primitive and produces as primitive a gall. However, only two species of this genus are known (the gall of one is not known) and, consequently, we are not warranted in making too broad generalizations. We may not be correct in considering this genus distinct from *Aulacidea*.

TIMASPIS

This genus, with seven known species, is not very distinct from *Aulacidea*. The galls of the two groups are equally simple and occur on plants of many genera. An indication of higher position, evolutionarily, is seen in the radial cell, which is usually partly open; and the second segment of the abdomen, though of about the same size in the female as in *Aulacidea*, is larger in the male, there covering about one-half of the abdomen.

AYLAX

We would include the following as belonging to the one genus: *Aylax* Hartig (= *Aulax* Hartig), *Isocolus* Förster, *Eubothrus* Förster, *Liposthenes* Förster, *Antistrophus* Walsh, *Asclepiadiphila* Ashmead, and

Gillettia Ashmead. This is the synonymy recognized by Beutenmüller (1910), and is practically that adopted by Kieffer (1910). The characters by which these various groups are separated seem hardly sufficient for drawing generic lines.

The radial cell throughout this genus is open, and in many cases the limiting veins are quite considerably reduced. This, without question, is more specialized than the closed cell of *Aulacidea*.

The first abscissa of the radius is usually arcuate, the more primitive condition, or may be slightly subangulate (as in *Aylax glechomæ*), which form of the vein is somewhat more specialized than the arcuate vein found in *Aulacidea* and the other species of *Aylax*.

Other indications of some specialization in the wing-venation are (1) the reduction of the veins bounding the areolet so that this cell is closed in most of the species of this genus, and (2) the lack of pigmentation and the fine form of the veins in practically every case, this condition appearing to result ultimately in the disappearance of the veins.

In most of the species the second segment covers only about one-third of the entire abdomen, a condition as primitive as that found in *Aulacidea*. But the dorsal extent of the plate in some of the species is somewhat greater, indicating greater specialization. In *Aylax pisum* (= *A. stephanotidis* Ashmead) the plate equals two-thirds of the length of the abdomen, though it is still small in lateral extent.

The hosts of this genus are as varied as the hosts of *Aulacidea*, including plants of at least sixteen different genera of seven natural families. This is the more primitive trait in the choice of hosts, as we have pointed out before.

The galls produced by the insects of this genus vary greatly in complexity. *Aylax rufus* produces no gall at all, living in the pith of stems, in this respect resembling *Aulacidea bicolor*, *A. abdita*, and *Phanacis centaureæ*. Most of the species produce decided swellings of the part affected, which is either stem, leaf, seed-capsule, or bracts, but the gall remains an integral part of the plant, more so in some cases than in others. Still other species form galls which are more or less separable from the plant, e. g., *A. kernei*, *A. salviæ*, *A. pisum*, and occasionally *A. glechomæ* and *A. latreillei*, and this represents a more complex condition. A character which holds for most of the species of this group, and one which indicates a more complex condition than any found in any of the species of *Aulacidea*, is the formation of distinct, but still inseparable, larval cells. The galls of some of the species (those which are inseparable from the plant) are polythalamous and agglomerate; the galls of

others are agglomerate but essentially monothalamous; the galls of four of the species (the galls which are separable from the plant), *A. glechomæ*, *A. kernei*, *A. pisum*, and *A. latreillei*, are distinctly monothalamous. No species of *Aulacidea* produces a gall which is monothalamous, or separable, or which develops distinct larval cells. The galls of *Aylax* are very evidently less primitive, though not all of the galls of this genus are as complex as others.

Reproduction in this group is most likely normal, sexual reproduction. The males of most of the species (not including *A. glechomæ*) are known, and the sexes are about equally well represented in collections, but I have not had an opportunity to breed large enough numbers of any of the species of the genus to obtain reliable data as to the ratio in which the sexes exist. *A. glechomæ* may regularly reproduce agamically.

There is no alternation of generations in *Aylax glechomæ* and *Aylax papaveris* (= *A. rhæadis* Bouché), as Adler proved (1881) by experimental breeding of the insects for successive generations. Nothing of the observations made on species of the genus concerning emergence dates, etc., would seem to indicate any likelihood of heterogeny occurring anywhere in the group.

In summary, species of *Aylax* are primitive in abdominal characters choice of host plant, degree of complexity of the galls of several species, and in manner of reproduction. The genus, however, evidently includes more specialized forms than *Aulacidea*, as evidenced by the specialized wing-venation, the enlarged second segment of the abdomen of some of the species, the more complex character of the galls of most of the species, and in the possible existence of agamic reproduction in one species. *Aylax glechomæ* is in many respects the most specialized of the species of *Aylax*. But in no cases do the species show as specialized characteristics as those of most of the oak gall-producing Cynipidæ.

I believe *Aylax* was derived directly from *Aulacidea*.

DIASTROPHUS

The radial cell in thirteen of the fourteen known species of this genus is open, indicating some degree of specialization, but the occurrence of the closed cell in one species, *D. fragariæ*, indicates that the group is descended directly from some closed-cell genus such as *Aulacidea*.

The first abscissa of the radius for most of the species is slightly angulate, but in a few species, e. g., *Diastrophus rubi*, it is still arcuate, the primitive condition. Evidently, there has occurred some evolution

of this character within the group, but the genus is closely related to, most likely descended directly from, *Aulacidea* or *Aylax*, the only genera where this vein is always arcuate.

The second segment of the abdomen of species of *Diastrophus* covers, dorsally, more than half the whole abdomen, in this respect being more developed than in *Aulacidea*, but not as developed as in *Rhodites* or most of the oak gall-producing cynipids.

The face of the species of this genus is peculiarly marked with fan-shaped striae. This is a sort of specialization not found elsewhere among the true gall-wasps.

The bidentate claws may be some indication of specialization. The claws of other groups of the Aulacini are simple.

The hosts of this genus are mostly plants of the family Rosaceæ. One species is on *Smilax*, a liliaceous plant. One species is found on *Fragaria*, four species are on *Potentilla*, and seven species occur on *Rubus*. Thus, the choice of host plant is rather wide, indicating a relationship to the primitive, polyphagous groups of the Aulacini. But over half of the genus is confined to *Rubus*, and another third to the related *Potentilla*, and this is a specialization of a degree much greater than that found in any of the other Aulacini, but it is not comparable with the complete specialization achieved by the Rhoditini and Cynipini.

The galls of this genus are remarkably uniform in degree of complexity of structure, all but one of the species producing galls which are agglomerate or polythalamous swellings of stems, quite inseparable from the plant, and to this extent quite primitive. But the forms of the galls are fairly definite, and the formation of larval cells which are slightly separable from the rest of the galls indicates some degree of specialization. The gall of *Diastrophus cuscuteformis* appears to be an exception to this general type, but this species may best be considered to belong to the genus *Gonaspis*. That is, the galls of *Diastrophus* indicate rather primitive, but somewhat developed, relationships.

Reproduction within the group may be normal sexual reproduction at times. I have often seen the males of *Diastrophus nebulosus* copulating with the females, and undoubtedly fertilization often occurs. But the males constitute only about thirty per cent of the total number of individuals, and it is very likely that this scarcity of males results in unfertilized eggs being laid very often, and the parthenogenetic development of these eggs is not unlikely. Again, we find an instance of the rather primitive (bisexual) nature of the species of *Diastrophus*, showing at the same time some degree of specialization, in the gradual disappearance of the males.

It is very doubtful if there is any alternation of generations within this genus. Adler (1881) has definitely proved, by the breeding of successive generations, that *Diastrophus rubi* has no alternation of generations, and nothing known concerning emergence dates, dates of appearance of the galls, etc., indicates that we should expect heterogeny in the group. Herein these insects are more primitive, less specialized than the oak gall-wasps.

GONASPID

This genus is clearly related to the genus *Diastrophus*, from which it is best distinguished by having the scutellum ending in a point which projects far over the metathorax. This indicates some degree of specialization beyond *Diastrophus*.

Another character which I feel is a good indication of specialization is the more complex character of the galls of *Gonaspis*. These galls are monothalamous and separable from the host plant (*Diastrophus* galls are polythalamous and inseparable) and show a considerable degree of separation of the zones, the epidermal layer in *G. potentillæ* being connected with the larval cell by distinct strands of tissue.

G. cuscuteformis also has a monothalamous, separable gall which is complicated with spinous processes, and the species evidently belongs in this genus, where Dalla Torre and Kieffer (1910) placed it. It has a scutellum which is more specialized than is usual in the genus *Diastrophus* and, although it is not as developed as in *Gonaspis potentillæ*, this character, taken in connection with the specialized gall of the insect, is enough to warrant considering the species to belong to *Gonaspis*.

RHODITINI

RHODITES

Including *Lytorhodites* Kieffer

The radial cell in this genus is closed in thirty species, but it is more or less open in six species, *R. arefactus* Gillette, *R. multispinosus* Gillette, *R. nebulosus* Bassett, *R. neglectus* Gillette, *R. ostensackeni* Beutenmüller, and *R. semipiceus* (Harris) [= *R. fulgens* Gillette]. The closed radial cell is found nowhere else in the family except in the group to which *Aulacidea* belongs, and it is not to be supposed that a closed-cell genus is evolved from other than a closed-celled genus. It appears that *Rhodites* is evolved, directly or indirectly, from *Aulacidea* or from a group from which they both originated. The species with the open radial cell show, in that respect, a higher development, and

give a clue to the evolution within the genus. Kieffer has established (1902, Bull. Soc. Metz, (2) X, p. 96) a distinct genus, *Lytorhodites*, for these species, but there seem hardly enough other distinctive characters to warrant making of the group more than a subgenus.

In *R. vernus* Osten Sacken (= *R. nodulosus* Beutenmüller) the first abscissa of the radius is arcuate, a primitive condition of the vein. The only other groups in the family where this vein is arcuate are some of the genera of the Aulacini, and *Rhodites* is most likely descended from one of the groups of that tribe. All the other species of the genus have developed an angulate vein, in this respect showing specialization, but even in most of these species the vein is only slightly angulate and has not developed the angle to any great degree.

The second abdominal segment throughout this genus is well developed, occupying a half to two-thirds of the whole abdomen. This is a more specialized condition of the segment than occurs in *Aulacidea* and a less specialized condition than in most of the species of oak gall-makers.

The hypopygium of the insects of this genus is a remarkably developed structure. It is broad and very acutely pointed, "plow-shaped." This is a very specialized form for that segment to assume; throughout the rest of the family it is quite inconspicuous and without a peculiar form.

The hosts of this group of gall-wasps are plants of the genus *Rosa*. Every known species of the genus occurs on roses. One species, *R. rosæ*, is believed to produce a gall, rarely, on plants of the related genus *Rubus* but, although this gall does resemble the mossy gall occurring on rose, I do not know that any one has bred the adult wasps from the blackberry gall and definitely proved the identity of the maker. Other records of species of *Rhodites* occurring on *Rubus* are undoubtedly errors in the determination of the host. There is no question that the insects are remarkably specialized in their choice of hosts. Compared with the distribution of the Aulacini upon plants of thirty-five different genera, this restriction of *Rhodites* (which genus contains about half as many species as the whole tribe of the Aulacini) undoubtedly indicates a higher degree of evolutionary development, a degree matched only by the concentration of the Cynipini upon the genus *Quercus* and only less remarkable than the specialization of the oak gall-makers because the number of the species of *Rhodites* is many times less than that of the Cynipini. The degree of specialization is complete in either case.

The galls produced by the insects of this genus vary considerably in degree of complexity. The galls of *R. vernus* and of *R. fusiformans*, for instance, are comparatively simple swellings of stems, entirely inseparable from the plant, and agglomerate or polythalamous—primitive characters. On the contrary, the galls of *R. bicolor*, *R. nebulosa*, *R. rosæ*, *et al.*, are very complex developments, entirely separable from the plant, highly modified in form, and with a high development of the larval cell. All degrees of complexity between these two extremes are to be found. The larval cell is distinct in most of the galls and has a well-developed wall, but in no case that I know of is the cell separable from the rest of the gall. That is, the galls indicate a wide range in the degree of development, evolutionarily, of various species of the genus, but in no case are the galls as highly complex, i. e., as highly developed, as in some of the genera of the oak gall-makers.

The mode of reproduction within the genus undoubtedly varies considerably among the species. It would be especially interesting to observe the reproduction of a species like *R. vernus*, for instance, which in wing-venation (arcuate first abscissa of the radius) and simplicity of the gall appears to be a more primitive form. It is possible that the reproduction of that species is primitive, normal, sexual reproduction. But it appears that, on the whole, the species of this genus reproduce agamically, with the males still existent but not usually abundant enough to fertilize many, if any, of the females. As Adler stated concerning this group, "The few males that are still produced are thus superfluous, and we can predict that they will probably become extinct in the course of time" (Adler-Straton, 1894, p. 153). Males are bred much less often than are the females and, from what limited data we can gather, they appear (cf. Table IV) to constitute only about two or three per cent of the total number of individuals. But this does not always apply to the progeny of any one individual; my first breeding of *Rhodites rosæ* gave six females and seven males, although subsequent breedings of the same species have only rarely given me any males at all. Gradually the male sex is disappearing from the genus and in consequence agamic reproduction is, likewise gradually, becoming the sole means of reproduction for these insects. Adler (1880) secured normal galls and insects from the unfertilized eggs of *Rhodites rosæ* and *R. eglanteriæ*, and there is thus no doubt that these unfertilized eggs are entirely capable of maturing. This agamy, almost completely achieved, is undoubtedly more specialized, more recently evolved, than the normal, sexual means of reproduction.

Adler (1880) proved by experimentally breeding for successive generations, that *Rhodites rosæ*, *R. eglanteriæ*, and *R. spinosissimæ* produce galls and adults in the second generation which entirely resemble the galls and adults of the parent generation, i. e., that there is no alternation of generations among these species such as occurs among the oak gall-makers. I have obtained a second generation of *Rhodites ignotus* which, similarly, is like the parent generation, and it is unlikely that alternation of generations occurs anywhere in the genus.

Summing our conclusions concerning the evolutionary position of *Rhodites*, we find that it shows primitive relationships in some respects but is more or less specialized in other ways. The closed radial cell of most of the species, the arcuate first abscissa of the radius of one species, and the simple galls of some species require that we derive the genus directly from some group as primitive as *Aulacidea*. However, the high specialization in the choice of host, the developed hypopygium, and the occurrence of agamy throughout the genus show a great degree of development beyond that attained by *Aulacidea*. The variation in the degree of specialization of the wing-venation and of the gall-structure indicates a considerable evolution occurring within the group itself.

CYNIPINI

NEUROTERUS

This includes *Neuroterus* Hartig, *Spathegaster* Hartig, *Ameristus* A. Förster, *Manderstjernia* Radoszkowski, and *Dolichostrophus* Ashmead.

In this group of oak gall-makers the radial cell is entirely or partially closed in six species, and in the remaining forty-eight species it is entirely open. This would indicate that the group, rather directly descended from the closed-cell genera *Aulacidea* or *Rhodites*, has had considerable evolution occurring within the genus itself.

The first abscissa of the radius shows considerable variation in *Neuroterus*, from a condition almost arcuate to a form very distinctly angulate with a slight projection into the radial cell. In no case, however, that I have examined is the vein as broadly and entirely arcuate as in the genus *Aulacidea*.

The second segment of the abdomen of species of *Neuroterus* is about one-half as long as the whole abdomen, being somewhat longer dorsally in the female but with a less extent laterally, so that the segment in this genus, though larger than in the Aulacini, is smaller than in the other oak gall-wasps. That is, there is closer relationship to the

Aulacini than is shown by this character by other genera of the Cynipini, and this suggests that in this group are the forms most like the ancestral Cynipini.

The galls of this genus are entirely restricted to oaks, the group showing in this respect the extreme specialization of the choice of hosts which is found in all the Cynipini and which is a remarkable condition.

The galls of *Neuroterus* are, on a whole, comparatively simple but there is some degree of difference in complexity of galls of various species. The differences, however, are not nearly as great as the differences between the galls of two genera of the oak-gall-producing cynipids. The galls of twenty-six species are polythalamous and inseparable, four species have monothalamous galls which are also inseparable, while twenty-two species have monothalamous galls which are separable from the plant. The polythalamous galls (the more primitive type) are always inseparable (a more primitive character); all but a few of the monothalamous (specialized) galls are separable (a specialized character). Some of the species are so primitive as hardly to produce a gall, e. g., *Neuroterus virgens* and *N. catesbaei*. Even in the most specialized galls the structure is never highly developed; there is no separation of parts; and there is no production of any abundance of new tissue or peculiar structures. The galls never consist of more than a rather simple wall surrounding the larval cell, rarely with a little simple pubescence, slightly peculiar shape, etc. The larval cell is sometimes quite distinct from the rest of the tissue of the gall, in some species much less so than in others but in no case that I know of is it separable from the rest of the gall. Again, in gall-structure, we find proof of the primitive nature of *Neuroterus*, more primitive than in any other group of the Cynipini but within the genus showing some considerable evolution. It is likely that further study of the galls may give further warrant for dividing the group into the several genera which have already been proposed for these species.

Reproduction in this group is so closely concerned with alternation of generations that it should be considered in that connection. The life histories of seven species have been studied and in every one of these cases heterogeny has been discovered. It is very likely that in most of the other species of the genus a similar heterogeny exists, but it is extremely important to discover whether all of the species have this sort of life history. The alternate generations, as far as known, always occur on similar parts of the plant, the galls appearing, superficially, rather different, but a closer study shows that in most instances they are of very

similar pattern. The galls of four of the European species studied are leaf-galls, all these being monothalamous and separable from the plant, with differences between alternate generations amounting to differences of form and not of plan of structure. The gall of the European *Neuroterus aprilius* is a bud-gall, the alternate of which is more distinctly different than with other species of this genus. The American species of *Neuroterus* of which the life histories are known show still less distinction between the galls of the two generations, having no greater differences than what would be necessitated by the differences in the state of the plant at the times of the year in which the galls are produced. The adults of the two generations in this genus are likewise very similar, differing primarily in being bisexual in one generation and agamic in the other. Concerning the European species Adler said (1881, p. 26): "If we compare the flies of the two generations belonging to any of the species above described, we shall find the differences at first sight very slight. The difference of colouring is unimportant, and is chiefly observable in a slight variation in the colour of the legs; nor is the size of the body very different, while the form and surface markings agree in many points." And he then pointed out that the only important differences are those of form of abdomen and of ovipositor, due to the different modes of reproduction of the two forms. Among our American species the differences between the adults of the two generations are even less marked. There is no doubt that the heterogeny found among the species of *Neuroterus* amounts to no more than seasonal dimorphism with agamic reproduction in alternate generations. This is in marked contrast to the great differentiation between alternate generations of the species of other cynipids where heterogeny occurs. No other instances of differentiation of alternate generations as slight as in *Neuroterus* are known among the other cynipids. Again we find proof that the genus *Neuroterus* is more primitive than the other oak gall-wasps.

In conclusion, we believe that *Neuroterus* is one of the most primitive groups of the Cynipini, derived rather directly from *Aulacidea*, and that a considerable evolution has occurred within the genus. Consequently, in this group we may expect to find the primitive stages of several of the biological characteristics of the oak gall-makers, and considerable attention given to the study of the life histories of species of *Neuroterus* is likely to be well repaid by discoveries which will cast light on the evolution of the highly specialized cynipids.

DISHOLCASPIE

Holcaspis Mayr (not of Chaudoir) is a synonym of *Disholcaspis* Dalla Torre and Kieffer.

In this genus the radial cell is open. In most cases the apical portion of the subcosta is very short or lacking and the radius terminates a considerable distance from the margin of the wing. This is the greatest reduction, the greatest specialization, of these veins, found regularly in any genus in the family.

The first abscissa of the radius in every instance is very angulate, the angle approaching ninety degrees, and the projection into the radial cell is always very distinct. This comes very near to being an extreme of the form assumed by this vein in the Cynipidæ—the extreme which we have considered the most highly specialized condition.

The second abdominal segment is not as highly developed as in many of the other oak gall-makers, though it is more developed than in the Aulacini. It regularly covers a half of the abdomen. These considerations, taken alone, would suggest that *Disholcaspis* is either more primitive than the rest of the Cynipini or that it has developed independently of most of those oak gall-makers.

The hosts of these insects is *Quercus*, these wasps showing the same extreme specialization in this choice of hosts as is characteristic of all of the Cynipini. Another sort of specialization shown by this group is the production of the galls of most of the species upon a single part of the plant—the lateral buds. It appears to be the stem that is affected, but M. T. Cook (1904, p. 143) pointed out that for at least some of the species it is really the bud that produces the gall. Most of the genera of gall-wasps include species which will attack the several parts of the plant, but in *Amphibolips*, *Cynips* (of European authors), and *Disholcaspis* the species of each genus are confined mainly to a single part of the plant. This seems to be specialization that, following generic lines, indicates something of the phylogenetic position of the group.

The galls produced by the species of *Disholcaspis* are among the most complex productions of the Cynipidæ. The galls are all monothalamous; they show a distinct separation of the zones resulting especially in the formation of the very distinct, highly modified wall of the larval cell, which in most species is entirely free in the central cavity of the gall; and the galls are only very slightly connected with the plant, in many cases leaving the host long before the insect has reached maturity. These are all characters indicating a high degree of specialization. In some cases the galls assume peculiar forms (e. g., *Disholcaspis fungi-*

formis) but the degree of complexity of plan of structure is absolutely uniform throughout the group. The only apparent exceptions to this rule are the best proof of the rule. Twenty-seven of the species are strictly of the sort described. The species called *Disholcaspis weldi*, *D. centricola*, *D. douglasi*, *D. maculipennis*, *D. brevipennata*, *D. arizonica*, and *D. truckeensis* produce galls which are very different from typical galls of *Disholcaspis*, but none of these species really belong to this group. The adults of the species *brevipennata*, *centricola*, *maculipennis*, and *weldi* have parapsidal grooves extending to the pronotum (not quite entire in *weldi*), have the second abdominal segment "tongue-shaped," i. e., produced dorsally, and in other ways are generically different from the species belonging in *Disholcaspis*, which genus was correctly limited by original definition to forms having the parapsidal grooves extending only to the middle of the mesothorax and the posterior edges of the second segment of the abdomen perpendicular or nearly so. Mayr (1902) very properly removed *centricola* and *douglasi* to the genus *Dryophanta*, with some of the species of which genus they have evident relationship; and there is as good reason for removing from *Disholcaspis* the other species listed above. Again, *arizonica*, which is apparently unknown except from the type material which I have not seen, is the only species included in *Disholcaspis* which has fifteen-jointed antennæ, and was first described (for reasons not evident from the description) as "closely related to *Cynips sulcatus* Ashmead, but differs by its much darker colour and infuscated wings. It seems to go best in *Holcaspis*" (Cockerell, 1902, p. 183). If this species differs from *Cynips sulcatus* mainly in color, it certainly does not belong to the genus *Disholcaspis*. Finally, *truckeensis* has the parapsidal grooves extending to the pronotum (only half as long in true *Disholcaspis*), has the cheeks almost as long as the compound eyes (only half as long in true *Disholcaspis*), and I have obtained it in both sexes (*Disholcaspis* is entirely agamic). That is, none of the apparent exceptions are truly exceptions to the rule of the uniformity of degree and sort of complexity of the galls of this genus. And such complete uniformity is not very likely mere coincidence but must be truly significant of the genetic relations of the insect producing the gall.

Reproduction in *Disholcaspis* must be entirely agamic. No males have ever been bred from or found in the galls of this group.

Whether alternation of generations occurs in *Disholcaspis*, with possibly bisexual reproduction in an alternate generation, is not definitely known. The genus is confined to America, so European workers have

not studied the life histories of any of the species. I have tried to breed the species for successive generations but, thus far, have not succeeded. Several of the species require two years or more for an insect to reach maturity and this makes the experimental study of these insects very difficult. All of the species, apparently, emerge in the winter. I have observed *D. globulus* ovipositing in the lateral buds of oaks but secured no galls from these buds. Whether a gall similar to that in which the parent insect matured would have resulted if the eggs had developed we cannot say positively.

Disholcaspis, then, is a genus which, in having an undeveloped second abdominal segment, shows what would appear to be a primitive character. But in wing-venation, restriction of the choice of host and of the part of the host affected, in the great complexity of gall-structure, and in completely agamic reproduction (in the one generation, at any rate), it shows great specialization, which is almost as great as that reached by any other genus of cynipids. It may be that the group is derived directly from the primitive oak-gall-producing Cynipidæ, becoming, however, very specialized. I cannot otherwise explain the persistence of the small abdominal plate. Knowledge of the life cycle of some of the species would throw considerable light on the question.

SUMMARY

The following are my conclusions which apply to the true gall-wasps:

1.—The closed radial cell of the wing is more primitive than the open cell; closed-cell genera or genera containing any species with the cell closed must be derived from closed-cell genera.

2.—The arcuate first abscissa of the radius is more primitive than the angulate vein showing a projection into the radial cell; the character of this vein is of generic importance and the extent of development toward the angulate vein indicates, in general, the extent of evolution of the genus.

3.—The size of the dorsal plate of the second abdominal segment is of generic significance; the smaller plate is more primitive; but this character among some Cynipini does not always show as great specialization as other characters in a genus, indicating diverse lines of evolution within the Cynipini.

4.—The primitive Cynipidæ were polyphagous; the restriction of *Diastrophus* mainly to *Potentilla* and *Rubus*, and the almost complete restriction of the Rhoditini to *Rosa* and of the Cynipini to *Quercus* show great specialization which occurred along three distinct lines of evolution.

5.—The form of the gall is an indicator of the specific nature of the insect and also of the generic relations of the insect; the degree of complexity of the gall-structure is likewise an expression of the generic position of the insect, the simplest galls being produced by the most primitive gall-wasps, and the more complex galls by more specialized wasps. The primitive cynipids were plant-tissue inhabiting, not gall-making, insects.

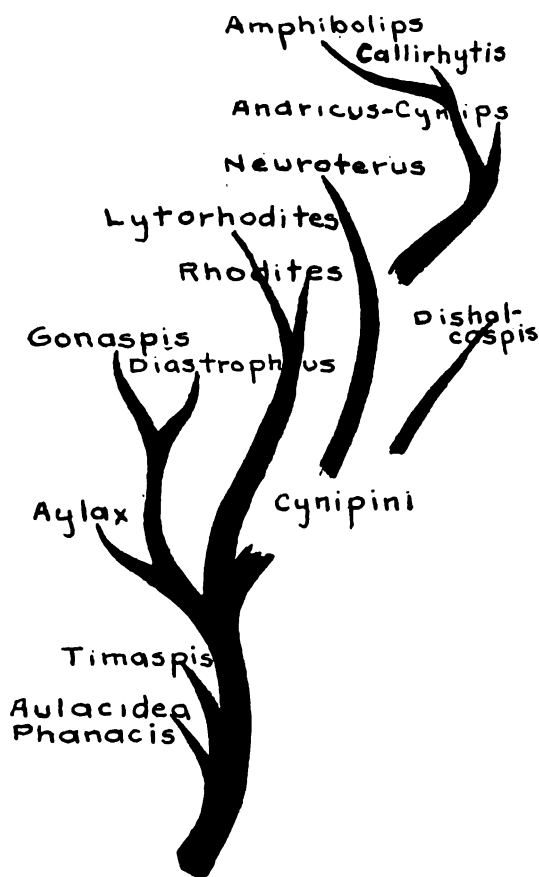


FIGURE 1. Relations of some cynipid genera.

6.—The primitive Cynipidæ were bisexual species with normal, sexual reproduction. By the gradual disappearance of the male and the gradual increase of parthenogenetic reproduction, species have become agamic at several times along distinct lines of evolution within the history of the gall-wasps.

7.—Alternation of generations is a development of seasonal dimorphism, a gradual evolution incited by the differences in the nature of existence in different parts of the host plant at different seasons of the year, and achieved after a struggle for the fixation of the new generation. Agamy is not the primitive method of reproduction; it is of great advantage to the winter generation of dimorphic cynipids, and may have originated because of this.

8.—The highly specialized phenomena characteristic of the gall-wasps (gall production, agamic reproduction, and heterogeny) are of doubtful advantage, with the apparent consequences of the loss of vitality, exposure to the force of many enemies, and the ultimate extinction of the insects.

9.—*Aulacidea* and *Phanacis* are in every respect the most primitive of the *Cynipidæ*.

10.—*Timaspis* is almost as primitive.

11.—*Aylax* is primitive, but shows some specialization.

12.—*Diastrophus* is derived from the *Aulacidea-Aylax* group.

13.—*Gonaspis* is a specialized development of *Diastrophus*.

14.—*Rhodites*, derived directly from *Aulacidea*, is highly specialized.

15.—*Neuroterus* is the most primitive of the *Cynipini*, and in that genus are to be discovered the incipient stages of some of the peculiar phenomena of the *Cynipidæ*.

16.—*Disholcaspis*, highly specialized in most respects, shows somewhat direct relationships to more primitive groups.

The conclusions concerning the origin of the fully studied genera may be summarized as shown in figure 1.

BIBLIOGRAPHY

The following brief bibliography includes only those papers which contain data of significance in the consideration of the phylogeny of the Cynipidæ, including some taxonomic papers on the genera here considered.

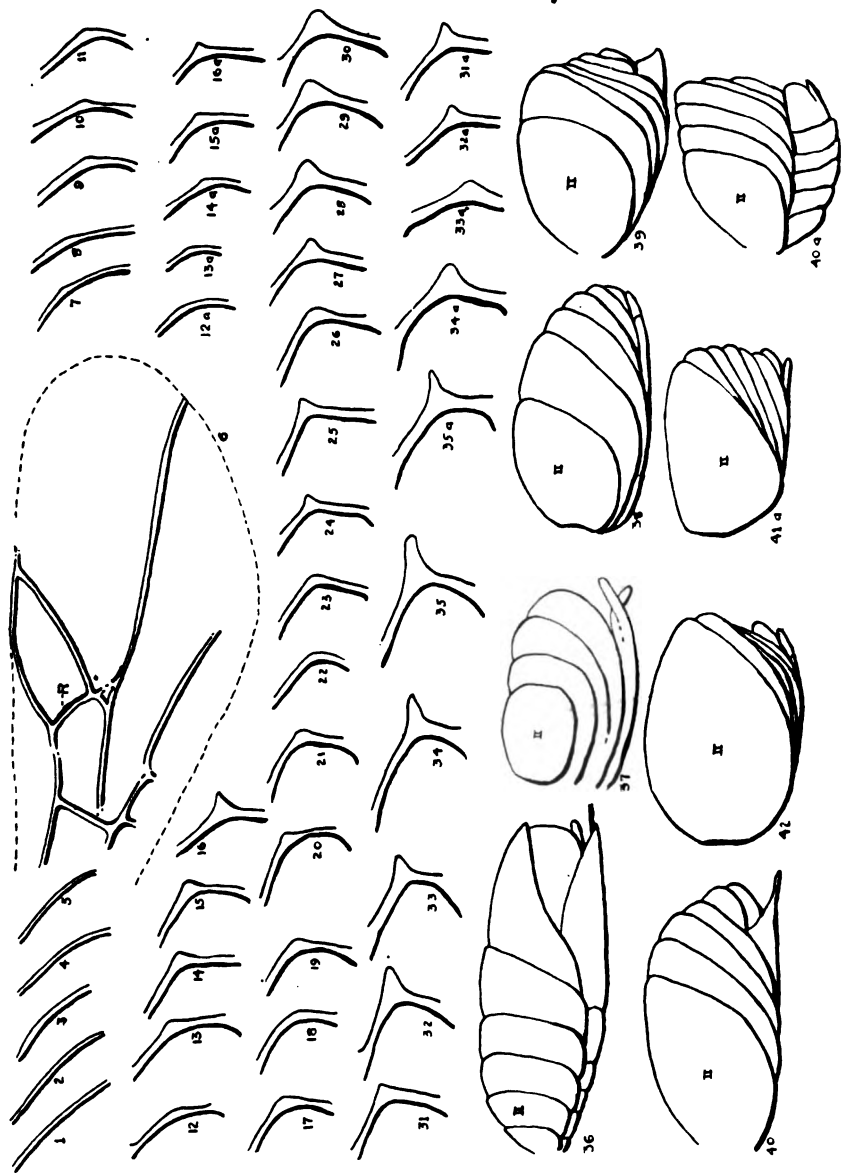
- ADLER, HERMANN. 1877a. Beiträge zu Naturgeschichte der Cynipiden. Deut. Ent. Zeit., XXI, pp. 209-248.
- 1877b. Lege-Apparat und Eierlegen der Gallwespen, idem, XXI, pp. 305-332.
1881. Ueber den Generations-wechsel der Eichen Gallwespen. Zeitschr. f. wissensch. Zool., XXXV, pp. 151-246. [Quotations of this paper are from Adler-Straton edition.]
- ADLER-LICHTENSTEIN. 1881. La Génération Alternante chez les Cynipides. [Lichtenstein trans. and edit.] Publ. M. Lichtenstein, Montpellier.
- ADLER-STRATON. 1894. Alternating Generations. [Straton trans. and edit.; quotations from this edit.] Oxford, Clarendon Press.
- ASHMEAD, WILLIAM H. 1903. Classification of the Gall-Wasps and the Parasitic Cynipoids, or the Superfamily Cynipoidea. Psyche, X, pp. 7-13, 59-73, 140-155, 210-218.
- BASSETT, HOMER F. 1877. Habits of Certain Gall Insects of the Genus *Cynips*; Agamic Reproduction Among the Cynipidæ. Proc. Amer. Ass. Adv. Sci., XXVI, pp. 302-306.
- BEUTENMÜLLER, WILLIAM. 1907. The North American species of *Rhodites* and their Galls. Bull. Amer. Mus. Nat. Hist., XXIII, pp. 629-651.
- 1909a. The species of *Holcaspis* and their Galls. Idem, XXVI, pp. 29-45.
- 1909b. The species of *Amphibolips* and their Galls. Idem, XXVI, pp. 47-66.
- 1909c. The North American species of *Diastrophus* and their Galls. Idem, XXVI, pp. 135-145.
- 1910a. The North American species of *Neuroterus* and their Galls. Idem, XXVIII, pp. 117-136.
- 1910b. The North American species of *Aylax* and their Galls. Idem, XXVIII, pp. 137-144.
- 1910c. The North American species of *Aulacidea* and their Galls. Idem, XXVIII, pp. 253-258.
1911. Two new species of *Holcaspis* from Mexico. Psyche, XVIII, pp. 86-87.
1915. A New *Diastrophus* on Strawberry. Can. Ent., XLVII, pp. 353-354.
- CAMERON, PETER. 1885. On the Origin of the Forms of Galls. Trans. Nat. Hist. Soc. Glasgow, V, pp. 38-41.
- COCKERELL, T. D. A. 1890. The Evolution of Insect-Galls. Ent., XXIII, pp. 73-76.
- COOK, MELVIN T. 1902-1904. Galls and Insects Producing Them. Ohio Nat., II, pp. 263-278; III, pp. 419-436; IV, pp. 115-147.
- COSENS, A. 1912. A Contribution to the Morphology and Biology of Insect Galls. Trans. Canad. Inst., IX, pp. 297-387.
- DALLA TORRE AND KIEFFER. 1910. Cynipidæ. Das Tierreich, XXIV.
- FELT, EPHRAIM P. 1918. Key to American Insect Galls. N. Y. State Mus. Bull., CC.
- KINSEY, ALFRED C. 1919. Fossil Cynipidæ. Psyche, XXVI, pp. 44-49.
- WALSH, B. D. 1864. On Dimorphism of the Hymenopterous genus *Cynips*; with an Appendix, containing hints for a new classification of Cynipidæ . . . Proc. Ent. Soc. Phila., II, pp. 443-500.

PLATE XXXII

Wing venation and Abdomen Characters of the Cynipidæ

First abscissa, radial vein

- Fig. 1. *Perichistus sylvestris*.
 - Fig. 2. *Ceroptres cicatricula*.
 - Fig. 3. *Synergus lignicola*.
 - Fig. 4. *Aulacidea succinea* (fossil).
 - Fig. 5. *A. bicolor*.
 - Fig. 6. *A. tumida* (R = first abscissa, radial vein).
 - Fig. 7. *A. annulata*.
 - Fig. 8. *Aylax leavenworthi*.
 - Fig. 9. *Diastrophus niger*.
 - Fig. 10. *D. nebulosus*.
 - Fig. 11. *D. radicum*.
 - Fig. 12. *Gonaspis cuscuteformis*.
 - Fig. 12a. *Neuroterus batatus bisexualis*.
 - Fig. 13. *Gonaspis potentillæ*.
 - Fig. 13a. *Neuroterus floccosus*.
 - Fig. 14. *Rhodites multispinosus*.
 - Fig. 14a. *Neuroterus vesiculus*, ♀.
 - Fig. 15. *Rhodites bicolor*.
 - Fig. 15a. *Neuroterus vesiculus*, ♂.
 - Fig. 16. *Rhodites bicolor*.
 - Fig. 16a. *Neuroterus irregularis*.
 - Fig. 17. *Andricus coronus*.
 - Fig. 18. *A. petiolicola*.
 - Fig. 19. *A. furnaceus*.
 - Fig. 20. *A. peredurus*.
 - Fig. 21. *A. singularis*.
 - Fig. 22. *A. futilis futilis*.
 - Fig. 23. *A. futilis radicolica*.
 - Fig. 24. *A. punctatus*.
 - Fig. 25. *Dryophanta dugesi*.
 - Fig. 26. *D. maculipennis*.
 - Fig. 27. *D. centricola*.
 - Fig. 28. *Disholcaspis globulus*.
 - Fig. 29. *D. cinerea*.
 - Fig. 30. *D. mamma*.
 - Fig. 31. *Cynips strobilana*.
 - Fig. 31a. *Andricus pomiformis*.
 - Fig. 32. *Cynips caput-medusæ*.
 - Fig. 32a. *Amphibolips cinerea*.
 - Fig. 33. *Cynips gallæ-tinctoriæ*.
 - Fig. 33a. *Amphibolips gainesi*.
 - Fig. 34. *Cynips calicis*.
 - Fig. 34a. *Amphibolips confluens spongiformis*.
 - Fig. 35. *Cynips kollari*.
 - Fig. 35a. *Amphibolips confluens aciculata*.
- Abdomen of Cynipoids (II = second segment)
- Fig. 36. *Ibalia maculipennis*, × 5.
 - Fig. 37. *Aulacidea progenitrix* (fossil), × 12.
 - Fig. 38. *A. bicolor*, × 25.
 - Fig. 39. *Diastrophus nebulosus*, × 16.
 - Fig. 40. *Rhodites dichlocerus*, × 20.
 - Fig. 40a. *Neuroterus batatus bisexualis*, × 25.
 - Fig. 41a. *Amphibolips cinerea*, × 10.
 - Fig. 42. *Andricus singularis*, × 20.



**Article VIII.—ADDITIONS TO THE ANT FAUNA OF THE WEST
INDIES AND CENTRAL AMERICA**

By WILLIAM M. MANN

During the winter of 1917-18 the writer spent several months in Cuba and one in the Bahamas, engaged in field work for the U. S. Bureau of Entomology. In the present paper are listed most of the ants collected during this time and, in addition, several from other localities, some of which were given to me by Prof. W. M. Wheeler and some received by the U. S. National Museum from other sources.¹

A number of the Cuban forms are those described by Roger in 1863 and not since seen by myrmecologists. Among these are the very interesting *Prenolepis gibberosa*, belonging to *Prenolepis sensu stricto*, *Camponotus sphaericus*, and *C. sphaeralis*, known hitherto only from the workers, which prove to be remarkable forms belonging to the subgenus *Colobopsis*. Twenty-two forms are listed as new to Cuba, which brings the number known from the island to ninety-nine. As Wheeler has noted (1913, Bull. Mus. Comp. Zool., Camb., LIV), the ant fauna is poor. The endemic species are mostly inhabitants of the forests and have disappeared in those districts that have been cleared. But even in the magnificent woods in the mountains of Oriente, Santa Clara, and Pinar del Rio, one does not find many species, though the majority of them belong to the older fauna. The desert region on the southeast coast, which has never been searched by myrmecologists, would certainly be productive of new forms, probably species related to those found in similar localities on Hayti.

The writer wishes to acknowledge with thanks his obligations to Mr. E. C. Holden of the Mina Carlota and to the officials of the Spanish American Iron Company at Felton, for facilities in travel and residence; and, in the Bahamas, to his Excellency, the Governor, Sir. Wm. Allardyce and to Mr. W. F. Doty, the U. S. Consul, for their kind interest and help.

Prof. W. M. Wheeler kindly gave the freedom of his collection to compare specimens and also aided me in certain identifications. The accompanying drawings were made by Miss Mary Carmody.

¹Cotypes of the new species are in the U. S. National Museum and The American Museum of Natural History.

PONERINÆ**Platythyrea punctata** (F. Smith)

SMITH, 1858, Cat. Hymen. Brit. Mus., part 6, Formicidæ, p. 108, ♀, ♂.

Bahamas:—Andros (Fresh Creek); Eleuthera.

Cuba:—Baracoa.

The specimens from Baracoa were found nesting in a hollow twig.

This species is nocturnal and, in the Bahamas at Fresh Creek on Andros Island, I saw workers foraging at night and taking small insects that had been attracted by the light I was using.

Euponera (Trachymesopus) stigma (Fabricius)

FABRICIUS, 1804, Syst. Piez., p. 400, ♀.

Bahamas:—Andros (Mangrove Cay).

Cuba:—Baracoa; Pinares; Mina Carlota; Felton.

I fail to find in a large series any specimens that can be identified as Roger's *succedanea*.

Ponera opaciceps Mayr

MAYR, 1887, Verh. zool.-bot. Ges. Wien, XXXVII, p. 536, ♀, ♀.

Cuba:—Guantanamo; Piedra Gorda; Pinares; Santiago de Cuba; San Blas; Mina Carlota.

Leptogenys (Leptogenys) puncticeps Emery

EMERY, 1890, Ann. Soc. ent. France, (6) X, p. 62, note, ♀.

Cuba:—Baracoa.

Several workers taken from a small colony beneath a stone are referable to the typical form of this species, which is known also from Costa Rica, Grenada, and Hayti.

Odontomachus hæmatoda (Linné) *notata*, new variety

The body is black as in the typical form, but the dorsal surface of the epinotum, the petiole, and the femora are rich brownish red in color; the apices of the femora, the tibiæ, tarsi, and the scapes are fuscous.

I propose this name for a color variety of *hæmatoda* from Monte Mandios, Porto Rico (Wheeler Coll.).

Odontomachus hæmatoda (Linné) subspecies *insularis* Guérin
variety *ruginodis* Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 82, ♀, ♀.

Cuba:—Santiago de Cuba.

Odontomachus hæmatoda (Linné) subspecies **insularis** Guérin
variety **pallens** Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 82, ♀, ♀, ♂.

Bahamas:—Eleuthera (Bluff).

Cuba:—Mina Carlota; Piedra Gorda; Baracoa; Guantanamo.

This is the commonest form of the species, both in Cuba and the Bahamas.

Odontomachus hæmatoda (Linné) subspecies **insularis** Guérin
wheeleri, new variety

Near var. *pallens*, but distinguished by having the dorsal surface of the epinotum and the entire petiole yellow in color in contrast to the red of the thorax and head. The legs are yellow, with the tarsi fuscous. The specimens are undoubtedly mature and fully colored and I consider them a local and very distinct color variety.

Four workers from Baracoa, Cuba (V. J. Rodriguez Coll.), given to me by Prof. Wheeler, are very characteristically colored.

MYRMICINÆ

Pseudomyrma elongata Mayr

MAYR, 1870, Sitz. Akad. Wiss. Wien, LXI, pp. 408–413, ♀.

Bahamas:—Andros Island (Mangrove Cay); Eleuthera (Bluff).

Pseudomyrma elongata Mayr variety **cubaensis** Forel

FOREL, 1901, Ann. Soc. ent. Belg., XLV, p. 342, ♀.

Cuba:—Havana; Cienfuegos; Limones; Santiago de Cuba; Cristo; Guantanamo; Baracoa, Felton; Pinares, San Blas, Guane.

Common and widely distributed. It is known as the "mordehuya," a name meaning "bite and run," very descriptive of its habits.

Pseudomyrma flavidula F. Smith

SMITH, 1858, Cat. Hym. Brit. Mus., part 6, Formicidæ, p. 157, ♀.

Bahamas:—Andros (Mangrove Cay); Eleuthera (Bluff).

On both visits to the Bahamas I have found the sexual phases of this species living with workers of *P. elongata*. Wheeler, who found the two species associated in a similar manner, but with workers of *flavidula* also present, on New Providence, has placed the record among cases of mixed colonies of exceptional or problematic character (Ants, p. 504). The females from these mixed nests are much smaller (length 4–4.25 mm.) than queens from ordinary colonies in the same localities (length 6 mm.) None are deâlated and some are not fully colored, evidently recently transformed individuals, which shows that they have developed in the same nests, indicating that *flavidula* is an occasional temporary parasite of *elongata*.

Pseudomyrma flavidula F. Smith variety **pazosi** Santschi

P. pazosi SANTSCHI, 1909, Bull. Soc. ent. France, p. 309, ♂, ♀.

Cuba:—Havana; Guane; Cienfuegos; Mina Carlota; Santiago de Cuba; Pinares; Cardenas.

Moderately abundant throughout the island.

Monomorium floricola (Jerdon)

Atta floricola JERDON, 1851, Madras journ. litt. sci., XVII, p. 107, ♂.

Cuba:—Cienfuegos; Santiago de Cuba.

Monomorium carbonarium F. Smith subspecies **ebeninum** Forel

FOREL, 1893, Trans. Ent. Soc. London, p. 388, ♂, ♀.

Bahamas:—Andros (Fresh Creek).

Cuba:—Yateras District; Guantanamo.

Monomorium (Xenomyrmex) stolli Forel subspecies **floridanus** Emery
variety **lucayanus** Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 87, ♂.

Bahamas:—Andros (Mangrove Cay).

One colony taken from a hollow twig.

Cardiocondyla emeryi Forel

FOREL, 1891, Grandidier's Hist. phys. nat. polit. Madagascar, XXII, pp. 160, 161.

Cuba:—Cabañas; (Wheeler Coll.).

Tetramorium lucayanum Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 101, fig. L, ♂.

FEMALE (deãlated).—Length 3 mm.

The mesonotum is striated longitudinally, similar to the head. The striæ of the scutellum are feeble basally and coarse apically. The postpetiole is longitudinally striate. Other characters are as in worker with the usual sexual modifications.

Cuba:—Cienfuegos; Cristo; Guantanamo.

Lives in small colonies beneath stones. The Cuban workers agree closely with the description of this species from the Bahamas.

Tetramorium simillimum (Nylander)

Formica simillima Nylander, SMITH, 1851, List Brit. Animals, Brit. Mus., part 6, Aculeata, p. 118, ♂.

Bahamas:—Andros (Fresh Creek).

Cuba:—Cristo.

This is the first Cuban record of this common tropicopolitan species.

***Tetramorium guineense* Fabricius**

FABRICIUS, 1793, Entom. System., II, p. 357, ♀.

Bahamas:—Andros.

Cuba:—Throughout the island. One of the commonest ants attending Coccidæ.

Macromischa

The genus *Macromischa*, besides containing some of the most exquisitely structured and beautifully colored species of ants, is of much interest in being the only one of what may be considered as truly Antillean genera that is well developed. The two ponerine genera, *Spaniopone* and *Emeryella* from Hayti and the myrmicine *Nesomyrmex* from Grenada, each known from a single species, as well as *Aphænogaster relictæ* and its variety *epinotalis* from Hayti, are undoubtedly relicts of an ancient and now almost extinct ant fauna, which has been replaced by numerous more recently introduced species. But *Macromischa*, belonging to this same endemic fauna, instead of dying out, has developed both in habit and structure into one of the most diversified myrmicine genera.

One-half, or fourteen, of the known species live in Cuba, the center of distribution; the others are scattered, two or three to each locality, on Hayti, Porto Rico, St. Thomas, the Bahamas, Central America, and one even as far as southern Texas. The number of undescribed, as compared with the known, species must be considerable and careful collecting in the West Indies, Central America and northern South America will surely yield many new forms. The species are extremely sporadic and often rare locally and hard to find. On New Providence, in the Bahamas, I searched for two days in the identical locality in which Wheeler found four colonies of *M. splendens* without finding it, but taking instead *M. allardycei*, new species. On Andros Island I found *M. pastinifera*, which was not taken by Wheeler, who found its variety *opacipes* and *M. androsana* on the same island. Of the six species taken during my five months in Cuba, only two species are referable to any of those taken by Gundlach and Poey, and described by Roger in 1863 and Wheeler in 1913.

The most usual nesting place for the known species is in hollow twigs. Some, as *affinis*, nest in rotten wood, and others, especially the small group that I separate as the subgenus *Antillæmyrmex*, in the ground. *M. sallei* and its variety *haytiana* build beautiful carton nests, which have been figured by Guérin (1852, Rev. Mag. Zool., II, Pl. iv) and Wheeler and Mann (1914, Bull. Amer. Mus. Nat. Hist., XXXIII, p. 36). The habits of the greater number of species are unknown.

The species belonging to the genus may be separated into more or less well-defined subgenera, as follows:

Subgenus *Macromischa* [type *M. purpurata* Roger], including *purpurata*, *porphyritis*, *squamifera*, *subdetiva*, *laevissima*, *sallei*, *androsana*, *pastinifera*, *affinis*, *fuscata*, *salvini*, *flavitaris*, *allardycei*, *splendens*, *scabripes*, *isabellæ*, *punicans*, *cressoni*, and *lugens*. This is still a heterogeneous grouping, but the various characters intergrade so much that a further division is not desirable until larger series can be studied.

Subgenus ***Cræsomymex***, new subgenus [type *Macromischa* (*Cræsomymex*) *wheeleri* Mann], including those species with unarmed epinota and elongate petiolar nodes—*wheeleri*, *iris*, *poeyi*, *gundlachi*, and *versicolor*.

Subgenus ***Antillæmymex***, new subgenus [type *Macromischa* (*Antillæmymex*) *terricola* Mann]. Small, hypogæic species, with rectangular heads and short peduncles to the petiole, including *terricola*, *pulchella*, *albispina*, and *flavidula*.

The following key, a modification of the one published by Wheeler (1908, Bull. Amer. Mus. Nat. Hist., XXIV, pp. 141–142) includes all of the known species with the exception of *lucayensis* Forel and *schwarzi* Mann, which are known only from females.

1. Species with metallic coloration 26.
Species without metallic coloration, or merely with violet reflections, on head or first gastric segment 2.
2. Epinotum unarmed 3.
Epinotum armed with spines 6.
3. Thorax with a profound meso-epinotal constriction; light red, with black antennæ and gaster; legs dark brown. Length 7 mm. (Cuba) .. *punicans* Roger.
Thorax without meso-epinotal constriction 4.
4. Dark red, the whole body with violet reflections; petiole three times as long as broad. Length 4 mm. (Cuba) *gundlachi* Wheeler.
Bicolored species 5.
5. Head and gaster black or dark brown; body red; femora with basal half thin and apical half suddenly strongly incrassated; thorax finely and densely punctate. Length 5 mm. (Cuba) *poeyi* Wheeler.
Femora less strongly incrassated. Thorax densely tuberculately punctate. Length 5.5 mm. (Isle of Pines) *versicolor* Roger.
6. Meso-epinotal constriction profound. (Mexico) *cressoni* Ern. André.
Meso-epinotal constriction obsolete or very feebly marked 7.
7. Small yellow species. Length 1.5–2.25 mm. 8.
Small species. Length 1.5–2.25 mm.; color, at least in part, black 9.
Larger or differently colored species 13.
8. Smooth and very shining. Length 1.5–1.7 mm. (Hayti).
flavidula Wheeler and Mann.

- Head and thorax, petiole and postpetiole sculptured and less shining. Length 2-2.5 mm. (Bahamas)..... *allardycei* Mann.
9. Petiole with a long slender peduncle, suddenly enlarged into an upright antero-posteriorly compressed scale..... 10.
Peduncle short, gradually sloping into the node which is not compressed antero-posteriorly. Subterranean species..... 11.
10. Head and thorax rugulose; epinotal spines shorter and stouter; hairs on body longer and more abundant. Length 2 mm. (Texas).... *subdetiva* Wheeler.
Head and thorax glabrous; epinotal spines longer and more slender; pilosity less abundant. Length 1.6 mm. (Mexico)..... *levissima* Wheeler.
11. Surface of body, except the gaster, very densely punctate and opaque. Length 2-2.25 mm. (Culebra and Mona I.)..... *albispina* Wheeler.
Surface of body, at least in part, shining..... 12.
12. Thorax glabrous above. Length 1.5 mm. (St. Thomas).... *pulchella* Emery.
Thorax punctate, though not densely, and less shining. Length 1.5-1.75 mm. (Cuba)..... *terricola* Mann.
13. Bicolored species, with at least the head or thorax red or yellowish..... 14.
Deep brownish red or black, or with a brown transverse band on each gastric segment..... 22.
14. Petiolar node rising abruptly from a long and slender peduncle..... 15.
Petiolar node gradually sloping from a shorter and thicker peduncle..... 21.
15. Jet black, except the head, which is red, and coxae and trochanters which are yellow; thorax and epinotum with strong and even transverse sulci. Length 3.5 mm. (Cuba)..... *scabripes* Mann.
Differently colored and sculptured species..... 16.
16. Larger species. Length 3.5-5 mm. Node rising abruptly from peduncle, but rather broadly rounded above, not strongly compressed anteroposteriorly and not bent forward at upper margin..... 17.
Smaller species. Length 1.9-2.6 mm. Node strongly compressed anteroposteriorly and distinctly bent forward at upper margin..... 19.
17. Petiolar node in profile longer than high, with anterior surface more rounded. Length 3 mm. (Cuba)..... *affinis* Mann.
Petiolar node in profile higher than long, with anterior surface more abrupt... 18.
18. Length 5 mm., form stouter; epinotal spines more thickened at base. (San Domingo)..... *sallei* Guérin.
Length 3.5-4 mm., form more slender; epinotal spines less thickened at base. (Hayti)..... *sallei* subsp. *haytiana* Wheeler and Mann.
19. Upper border of petiole node bent forward but slightly; head, postpetiole and gaster black. Length 1.9-2 mm. (Bahamas)..... *androsana* Wheeler.
Upper border of petiole much curved forward, both head and thorax red... 20.
20. Legs shining. Length 2.6 mm. (Bahamas)..... *pastinifera* Emery.
Legs opaque, finely and densely punctate. Length 2-2.5 mm. (Bahamas) *pastinifera* var. *opacipes* Wheeler.
21. Petiolar node laterally compressed, with a conical summit; epinotal spines very small and erect; head, gaster and femora black; thorax, petiole and postpetiole red; tibiae and tarsi yellow; head and thorax opaque. Length 3.5-2.7 mm. (Porto Rico)..... *isabellæ* Wheeler.

- Petiolar node not laterally compressed; epinotal spines long and slender and pointing backward; brown, gaster black. Length 3 mm. (Cuba).
affinis Mann.
22. Large species (length 6–6.5 mm.); surface opaque; head and gaster with faint violet reflections. (Cuba).....*lugens* Roger.
 Smaller. (Length 3–3.5 mm.). At least somewhat shining..... 23.
23. Petiolar node gradually sloping from the peduncle, from above longer than broad and not compressed anteroposteriorly. Length 3 mm. (Guatemala).
fuscata Mann.
- Petiolar node rising abruptly from the peduncle; from above twice as broad as long..... 24.
24. Thorax above finely striate and punctate and shining; epinotal spines much longer than their distance apart at base. Length 3 mm. (Guatemala).
flavilarsis Mann.
- Thorax above coarsely rugose and subopaque; epinotal spines shorter and thicker. Length 4–4.2 mm..... 25.
25. With a brown transverse band on each gastric segment; antennal scapes reaching or barely surpassing occipital corners. (Panama)....*salvini* Forel.
 Gaster entirely brown; scapes distinctly surpassing the occipital corners; femora less incrassated; peduncle of petiole longer and more slender. (Panama).....*salvini* var. *obscurior* Forel.
26. Epinotum unarmed..... 27.
 Epinotum armed with long spines..... 28.
27. Head opaque, densely punctate; nodes, gaster and femora dark metallic green or brown; pedicel yellowish brown; tibiae, tarsi, and funiculi lighter brown. Length 5–5.5 mm. (Cuba).....*iris* Roger.
 Head smooth and very shining; metallic green throughout, except tarsi, which are brownish. Length 3.75–4 mm. (Cuba).....*wheeleri* Mann.
28. Greater portion of head glabrous..... 29.
 Head, at least on front, rugose or striate..... 30.
29. Body shining metallic green with violet reflections; nodes of petiole and postpetiole brown, shining, with metallic green or blue reflection; peduncle of petiole and articulations honey-yellow; scapes light brown. Length 4 mm. (Cuba).....*squamifera* Roger.
 Nodes of petiole and the postpediole jet black; antennal scapes dark brown to black. (Cuba).....*squamifera* var. *atrinodis* Mann.
30. Petiole as long as the thorax, very slender; epinotal spines long and slender; thorax irregularly rugose; head finely striate in front, smooth above; violet in color, thorax red, passing into violet on the pleurae. Length 5–6 mm. (Cuba).....*purpurata* Roger.
 Petiole not as long as thorax; less elongate and differently colored species... 31.
31. Head and thorax densely punctate and purplish red, with violet reflections and silky lustre; gaster black. Length 5–5.5 mm. (Cuba)....*porphyritis* Roger.
 Thorax covered with strong, regular arcuate, transverse rugae; head with dense longitudinal rugae; head and thorax deep metallic green, passing into violet on the cheeks, pleurae and epinotum; mandibles, clypeus, frontal carinae, neck, terminal tarsal joints, and anterior end of petiolar peduncle dull orange; remainder of petiole, postpetiole, gaster, and legs black; coxae, trochanters and extreme bases of femora honey-yellow. Length 3–3.5 mm. (Bahamas).....*splendens* Wheeler.

***Macromischa (Macromischa) purpurata* Roger**

ROGER, 1863, *Berliner Ent. Zeitschr.*, VII, p. 184, ♀.

WORKER.—Length 5-6 mm. (Fig. 1).

Form slender. Head oval, narrowed behind, corners rounded and occipital margin straight. Mandibles stout, five-toothed. Clypeus rather strongly notched at anterior border. Antennæ short, their scapes not attaining occipital margins; first and second funicular joints twice as long as broad, the remaining joints gradually increasing in size to the club; terminal joint longer than the two preceding joints together. Prothorax evenly rounded at sides, not much broader than the mesothorax; sides of meso- and epinotum subparallel. Epinotal spines rather thick at basal half and very slender apically, divergent and curving slightly upward. Peduncle of petiole exceedingly slender, as long as the femora, gibbous at sides posterior to the middle; node less than a third as long as the pedicel, high and rounded above and in front, sloping behind; from above about twice as long as broad, with sides rounded in front. Postpetiole bell-shaped, nearly three times as broad behind as in front. Femora and tibiæ incrassate.

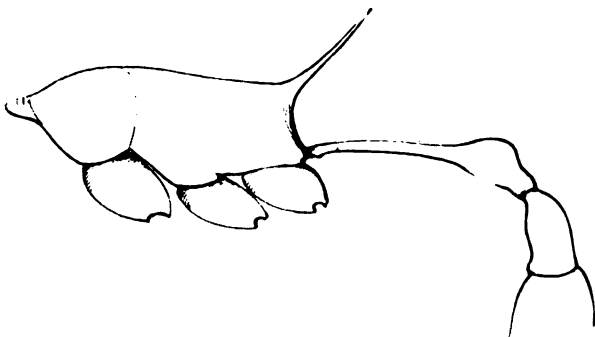


Fig. 1. *Macromischa (Macromischa) purpurata* Roger, ♀. Thorax and petiole from side.

Body and appendages shining. Mandibles with sparse and coarse punctures and short longitudinal striæ. Clypeus with a longitudinal carina at middle. Front and cheeks with separated curved striæ, some of which are concentric with the eye and others extend medially on the occiput; sides of occiput smooth. Thorax and epinotum with coarse rugæ which are longitudinal on pronotum and very irregular behind. Petiole, postpetiole, gaster, legs and antennæ finely punctate. Hairs on body and appendages long, fine and erect.

Head black, with violet reflections. Thorax and epinotum red; petiole and postpetiole brown to dark brown, gaster and appendages black.

FEMALE (deâlated).—Length 6 mm.

Differing from the worker in the much finer sculpture of the thorax. The scutellum is twice as broad as long and broadly impressed longitudinally at middle. The epinotal spines are short and triangular, basally as broad as long. The pedicel is very much shorter and stouter than in the worker.

Cuba:—Pinares (Oriente).

The exceedingly long petiole, with the low, rounded node, the long epinotal spines, and the beautiful coloration make this one of the most striking species of ants.

The three colonies that I found were in deep woods near the Woodford Inn at Pinares, one in a hollow twig on the ground, one in a twig that was dangling at the end of a slender vine and one among the suckers at the base of a *Tillandsia*. Several foraging workers seen on leaves and fern fronds were moving leisurely about and were holding the gaster in a horizontal position. When excited, they bent it somewhat downward.

My specimens agree well with Mayr's description, except that the petiolar spines and legs are very dark reddish brown to black. They may represent a local variety, as the types were from Yateras and Santiago de Cuba on the other side of the island and all of the species are very local, but I prefer to consider the series before me as typical, until I see others with light brown legs and epinotal spines.

Macromischa (Macromischa) squamifera Roger **atrinodis**, new variety

WORKER.—Length 4 mm. (Fig. 2).

Head a little longer than broad, occipital angles broadly rounded; border nearly straight. Surface of clypeus rather flat; anterior border straight. Antennæ short, their scapes not quite attaining the occipital corners; first funicular joint about as long as the next two joints together; club moderately well defined, with the first two joints subequal in length and the terminal joint as long as both the others together. Eyes convex, situated at middle of sides of head. Thorax robust, without distinct sutures. Epinotal spines about as long as peduncle of petiole, slender and nearly straight. Peduncle more than twice as long as node, toothed anteroventrally and tuberculate at sides a little behind middle; node shorter than high; from above more than twice as broad as long, and strongly narrowed at sides. Postpetiole a little broader than petiole, nearly as broad in front as behind. Femora and tibiæ strongly incrassated.

Shining throughout. Head sparsely punctate above; rugulose on cheeks, clypeus and between frontal carinæ. Mandibles striate. Antennæ striolate and punctate. Thorax transversely rugose, the rugæ on pronotum being more widely separated and less regular than those on the meso- and epinotum. Petiole, postpetiole, gaster, and legs finely punctate.

Hairs scattered, coarse and erect.

Color violaceous black to blue, the violet varying as the light changes, most pronounced on the occiput and thorax and less on the gaster. Mandibles and antennal scapes brownish. Peduncle of petiole, tips of coxæ, trochanters, and base of femora yellow.

FEMALE (deâlated).—Length 6.5 mm.

Epinotal spines shorter than in the worker and femora proportionally less swollen. Ocelli large. Pronotum coarsely and irregularly striated transversely. Striæ of mesothorax and scutellum finer and more rugose than in the worker.

Cuba:—Mina Carlota (Trinidad Mts.).

The workers in my series agree with Roger's description of *squamifera*, except that the petiolar node and postpetiole are jet-black in color and not brown.

Several colonies of this beautiful species were found in the woods about the mine. During my first visit, in November, the weather was cold and misty, and this species was, with the exception of a few *Tetramorium guineense* workers, the only ant that I observed foraging.

It nests in hollow twigs, sometimes in live plants but preferring small ones on the ground, in humid woods. Apparently it is not rare, but is very local. On December 24, I hunted the entire day without finding a single specimen; on the 25th I found, in practically the same part of the

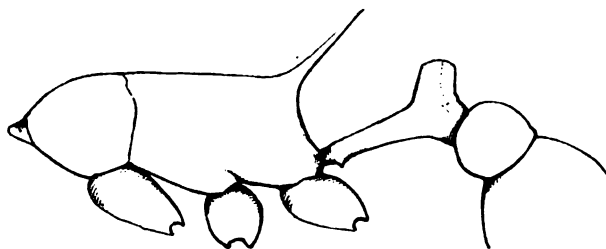


Fig. 2. *Macromischa (Macromischa) squamifera* Roger var. *atrinodis* Mann, ♀. Thorax and petiole from side.

woods, eight colonies. The workers are timid. When a twig containing a colony is broken, some come out and attempt to sting, but the sting is too feeble to make itself felt.

Several colonies were kept alive for more than a month. While getting them to leave the twigs that I had broken and to enter others, I put them in a box over a pan of water. Many of the workers fell into the water and apparently drowned. I afterwards put these half-drowned workers back in the box and the others cleaned them of water and carried them into the nest. About fifty workers were "salvaged" in this manner. They were seized by the mouth-parts, with the pedicel held backward over the body of the bearer, and carried in this manner. They all recovered, for no dead ones were afterwards brought out of the twigs.

***Macromischa (Macromischa) porphyritis* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 185, ♀.

WORKER.—Five to $5\frac{1}{2}$ mm. long and slender; head and thorax purple-red with violet reflection, with rather opaque silky lustre. Petiole and legs shining yellowish brown; abdomen black, shining. The whole body, especially the antennæ and legs, with whitish, erect pubescence.

Head oval, moderately narrowed posteriorly. Eyes towards the sides in the middle. Mandibles with four to five teeth, strongly striate longitudinally. Clypeus between the antennæ triangular, truncated behind, feebly carinate in middle; towards the carina, obliquely rugose. Frontal area triangular, not sharply defined; longitudinally rugose, opaque. Antennal grooves not as large and deep as in the preceding species. Antennæ black with blue or violet lustre; scape extending considerably beyond the hind margin of head, indistinctly striate, first funicular joint as long as the two following; last four joints are much longer than wide and form a feeble club. Head densely punctate "thimble-like" and irregularly longitudinally rugose.

Pronotum rounded laterally, constricted before mesonotum, "thimble-like" punctate, and besides especially apically, moderately densely rugose longitudinally. Rest of the thorax transversely and on the sides longitudinally rugose. Thoracic sutures absent, but between the pro- and mesonotum one sees indicated a feeble semi-circular impression. Epinotal spines very long, slender, directed posteriorly and above, and in the middle feebly bent angularly.

Petiole very long, slender, when viewed from above feebly angularly dilated at middle, and swollen behind into a low rounded node. Postpetiole bell-shaped, somewhat wider than the first, both are smooth. Abdomen long and oval, first segment the largest. Femora slightly, the tibiæ not at all swollen, more slender than in the preceding species. [Translation.]

Cuba:—One worker; (Roger).

***Macromischa (Macromischa) pastinifera* Emery**

EMERY, 1896, Bull. Soc. ent. Ital., XXVII, p. 28, Pl. I, fig. 18, ♀.

Several workers were taken running about on the ground in a pine yard near Fresh Creek on Andros Island, Bahamas.

***Macromischa (Macromischa) allardycei*, new species**

WORKER:—Length 2–2.50 mm. (Fig. 3).

Head longer than broad, as broad in front as behind with feebly convex sides and occipital border. Mandibles with five teeth. Clypeus convex, tricarinate; anterior border straight. Antennæ short, scapes extending about two-thirds the distance to occipital corners in the smallest workers and three-fourths in the largest; first funicular joint more than twice as long as the two following joints together; joints three to eight twice as broad as long; club well-defined, as long as the rest of funiculus, with the first and second joints only slightly longer than broad and the terminal joint distinctly longer than the other two together. Eyes large and convex; situated at middle of sides of head. Thorax robust, without sutures, slightly tapering from greatest width (at anterior part of pronotum) to the epinotal declivity. Epinotal spines widely separated at base, longer than peduncle, sickle-shaped, curved downward and moderately divergent. Petiole with a thick peduncle, shorter than the node, armed anteroventrally with a strong, elongate tooth; node longer than high, dorsal surface broad (in profile but slightly convex), anterior and posterior surfaces sloping; from above evenly tapering into the peduncle, with two minute lateral tubercles a little in front of middle. Postpetiole a little broader than the petiole and broader than long; slightly narrowed in front, with moderately rounded sides. Gaster short and broad. Sting very feeble. Femora and tibiæ somewhat swollen.

Shining throughout. Mandibles striate. Head, thorax, epinotum, and petiole reticulately carinulate, with the intermediate spaces foveolately punctate and rugulose. Postpetiole rugulose. Gaster and legs minutely punctate and more shining than the rest.

Erect, stiff, acuminate, yellowish hairs moderately abundant on head, body and appendages.

Color uniformly testaceous.

FEMALE (deâlated).—Length 3.25 mm.

Head about as long as broad, broadest behind. Epinotal spines stout, triangular, shorter than their distance apart at base. Petiolar node shorter and deeper than in the worker, and more declivous in front. Postpetiole twice as broad as long.

Head, epinotum, petiole and postpetiole sculptured as in the worker. Mesonotum and scutellum with very fine longitudinal striæ and sparse, foveolate punctures.

Color darker than the worker, with the mesonotum and gaster and a spot at the ocelli, ferruginous, and the margins of the mesonotum and scutellum fuscous.



Fig. 3. *Macromischa* (*Macromischa*) *allardycei* Mann, ♀. Thorax and petiole from side.

Bahamas:—New Providence.

A small colony of this species, which is dedicated to Sir William Allardyce, Governor of the Bahamas, a naturalist himself and a friend of naturalists, was found in a hollow stem of *Cladium jamaicensis* on the borders of a swamp on the road between Grants Town and the Blue Hills.

The structure of the head and the petiole are very distinctive. The most curious thing about the species is the presence of some degree of polymorphism, one worker, the largest in the series, having the head proportionately broader than the others and the epinotal spines bent slightly upward. In general habitus *allardycei* resembles a large *Leptothorax*.

***Macromischa* (*Macromischa*) *schwarzi*, new species**

FEMALE (deâlated).—Length 4.5 mm.

Head, excluding the mandibles, a little broader than long, considerably broader behind than in front, with rounded corners and nearly straight occipital borders. Mandibles with five small separated teeth. Clypeus convex basally and concave at anterior border. Eyes situated at middle of sides of head. Ocelli small. Antennæ stout, their scapes slightly surpassing occipital corners; first funicular joint nearly as long as the three following joints together; joints two to eight transverse; terminal

joint of the club slightly longer than the two preceding joints together. Thorax robust, flat above. Mesothorax a little broader than longer. Scutellum twice as broad as long. Epinotal base and declivity rounding into each other. Epinotal spines stout, divergent and slightly curved, their length equal to the height of the petiolar node. Peduncle of petiole much longer than the node, with a small ventral tooth a little in front of the middle. Node in profile deeper than long, narrow above, with a declivous anterior and a rounded posterior face; from above more than twice as broad as long, impressed medially and narrowly rounded at sides. Postpetiole short, one and a half times as broad as the petiole, nearly twice as broad as long and broadest in front. Sting powerful. Femora and tibiae moderately incrassated.

Moderately shining. Mandibles striate. Head and mesonotum finely and densely striate longitudinally; remainder of body and the appendages very finely punctate, the punctation of the postpetiole more dense.

Scattered erect hairs present throughout. Gaster with sparse, short, recumbent hairs.

Color brownish red, the gaster somewhat darker than the rest.

Cuba:—Cayamas; (E. A. Schwarz). One specimen.

Very distinct from the other Cuban species. The petiolar node in profile is somewhat bent forward at its upper anterior margin similar to, but less than in, *androsana*. The small size, color, and lack of metallic lustre distinguish it from the other Cuban species that have a similarly anteroposteriorly compressed petiolar node.

***Macromischa* (*Macromischa*) *scabripes*, new species**

WORKER.—Length 3.5 mm. (Fig. 4).

Head longer than broad, slightly narrowed in front, with convex sides, broadly rounded occipital corners and straight border. Mandibles 5-dentate. Clypeus rounded basally, very shallowly concave at anterior border. Antennae short, scapes not attaining occipital corners; funicular joints three to eight a little broader than long, club distinct, the terminal joint slightly longer than the two preceding taken together. Eyes convex; situated at middle of sides of head. Thorax robust. Prothorax rather flat above, with rounded sides and humeri and a pronounced neck in front; a little broader than the mesonotum. Pro-mesonotal suture not discernible. Basal and declivous portions of epinotum rounding into each other and not distinct. Epinotal spines short and stout, curving moderately downward, shorter than the distance from their bases to posterior margin of declivity. Peduncle of petiole twice as long as the node, bisinuate below and bluntly toothed at sides beneath node; node thick, in profile higher than long, broadly rounded above; the anterior surface slightly convex and the posterior more flattened; from above less than twice as broad as long, rounded at sides and in front and straight behind. Postpetiole a little longer than high; from above about as long as broad, rounded at sides and in front. Femora strongly incrassated, the tibiae moderately so. Sting moderate.

Body and appendages shining. Mandibles and antennal scapes striate. Head irregularly, densely rugosely striate. Thorax and epinotum with a series of about twenty-eight strong sulcae, which extend transversely across the dorsum and con-

tinæ diagonally on the pleuræ. Petiole, postpetiole and gaster minutely punctate and shining. Femora tuberculate, the tubercles small and scattered; the intermediate surface irregularly striolate; tibiæ with short, but rather strong striæ.

Hairs coarse, and erect and white; moderately abundant on head, body, and appendages.

Head, base of mandibles and anterior portion of prothoracic collar brownish red; coxæ and trochanters yellow, the rest black; thorax and epinotum with greenish lustre.

Cuba:—Saetia (Oriente).

The prominent tuberculated femora and the strongly sulcated thorax and epinotum are characteristic. There is a greenish reflection to the thorax. *M. splendens* Wheeler from the Bahamas is the species nearest to *scabripes*, but the two are very distinct.

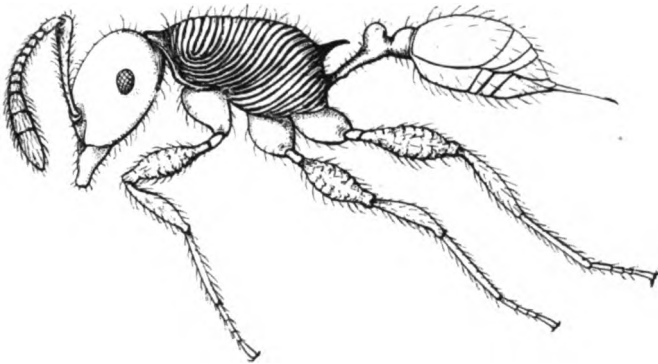


Fig. 4. *Macromischa (Macromischa) scabripes* Mann, ♀. Lateral view.

The two workers from which the species is described were found in dry open woods at an altitude of about two hundred feet. They were running very rapidly over the leaves of a shrub and while moving carried the gaster bent downward and forward beneath the body so that the insect appeared to be only half as long as it really was. This manner of carrying the gaster is more or less characteristic of all the species but is most extreme in *scabripes*. In *squamifera* the gaster is held perpendicularly, in *wheeleri* it is less bent and in *purpurata* scarcely at all downward, except when the insect is excited.

***Macromischa (Macromischa) affinis*, new species**

WORKER.—Length 3.25–3.50 mm. (Fig. 5).

Head ovate, longer than broad, with straight posterior border. Mandibles stout, 5-dentate. Clypeus flattened above, with a median longitudinal and two lateral curved carinæ; anterior border narrowly but distinctly concave at middle. Eyes strongly convex, situated at middle of sides of head. Antennæ slender, their scapes

slightly surpassing the occipital borders; first funicular joint as long as the two succeeding joints together; club poorly defined, its terminal joint a little shorter than the other two together. Thorax and epinotum two and a half times as long as broad; pronotum scarcely broader than epinotum. Epinotal spines as long as petiolar peduncle, rather thick at basal half, curving downward at middle, with the tips bent distinctly upward. Peduncle of petiole slender, about as long as node, with a small angular tooth anteroventrally and tubercles at base of node; node longer than high, broad and feebly rounded above, with sloping anterior and posterior surfaces; from above, longer than broad, with rounded sides. Postpetiole one and a half times as broad as petiole, a little broader than long; seen from the side, longer than high and rather flat above. Gaster short; sting large. Femora incrassate and tibiae almost as strongly so.

Shining, the gaster and legs much more strongly than the rest. Mandibles and scapes finely striate and punctate. Head, thorax and epinotum densely and coarsely rugose punctate longitudinally. Petiole and postpetiole with concentric striae; gaster and legs smooth.



Fig. 5. *Macromischa (Macromischa) affinis* Mann, ♀. Thorax and petiole from side.

Long and fine white pubescence rather abundant on head, body and appendages.

Antennae, gaster, border of mandibles, apical half of femora, base and apex of tibiae and the tarsi black, the rest rufo-testaceous.

Cuba:—Felton; Piedra Gorda.

Described from several workers taken on leaves in dense woods and from one small colony in rotten wood. The general appearance in life is very much like that of a *Tetramorium*. This species resembles *sallei* subsp. *haytiana*, but is smaller, the petiolar node rises less abruptly from the peduncle, the thorax is more robust and the sculpture and color different.

***Macromischa (Macromischa) punicans* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 189, ♀.

WORKER.—Length 7 mm.

This species differs from the other species of the genus in having a saddle-shaped impressed thorax and also in having a more square than oval head, and finally in the postpetiole not being bell-shaped, but quadrate. But since the petiole is moderately long and since the middle and hind tibiae are without terminal spurs I have placed this species here.

Light red with black antennæ and abdomen, legs dark brown. Head slightly shining; thorax and petiole opaque; abdomen and legs very strongly shining. Yellowish erect hairs scattered everywhere. Head almost quadrate, rounded at angles. Clypeus convex, longitudinally striate, posteriorly smooth and shining. Frontal area indistinct. Mandibles with five teeth, the two anterior ones strongest. Mandibles longitudinally rugose. Antennal fossæ small; scape stout, of uniform thickness, reaching the hind margin of the head. First funicular joint as long as the two following joints, remaining joints as broad as long and approximate; club three-jointed. Head densely striate longitudinally. Pronotum convex, rounded laterally, depressed posteriorly; mesonotum deeply impressed transversely as in *Aphenogaster*; epinotum more elevated, rounded, without spines. Entire thorax densely punctate, pro- and mesonotum besides irregularly rugose. Petiole not as much produced cylindrically in front as in the other species. It gradually thickens from base to the moderately high node, but it has in the middle small lateral tubercles and a small tooth antero-ventrally. Postpetiole elongate quadrate with rounded corners. Both nodes feebly rugose. Abdomen smooth, very shining, its first segment much the largest. Legs comparatively short, femora thickened, rounded, tibiæ moderately short and somewhat thickened. Posterior metatarsi shorter than the femora. [Translation.]

Several workers from Cuba; (Roger).

According to Wheeler, who looked up Gundlach's notes on the Cuban ants, this species was found at Santiago de Cuba and Monte Toro in the mountains of Guantanamo.

Macromischa (Macromischa) lugens Roger

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 188, ♂.

WORKER.—Length 6–6.5 mm.

Black, opaque, abdomen feebly shining, with bluish reflections; head when viewed in certain lights with very feeble violet reflection. Legs dark brown, shining and as well as the whole body, beset with white hairs. The oval head is densely "thimble-like" punctate, not shining, at sides in front of eyes longitudinally rugose. The "thimble-like" punctate clypeus anteriorly with curved, posteriorly with longitudinal rugæ. Frontal area in the middle with strong, laterally with weaker longitudinal rugæ. Mandibles coarsely longitudinally rugose.

Pronotum feebly and somewhat angulately widened at sides, behind the angle somewhat constricted, but elsewhere of equal width, above slightly convex, not impressed, very coarsely rugose longitudinally. Petiole moderately elongate in front, posteriorly enlarged into a moderately high rounded node, without ventral tooth, "thimble-like" punctate with some longitudinal rugæ. Postpetiole bell-shaped and as well as gaster indistinctly and very finely rugose. Legs long, femora thickened in front of middle, tibiæ very long and slender. [Translation.]

One worker from Cuba; (Rogers).

Gundlach's notes state that this species was taken in the "highland of Camoa." This is an indefinitely defined region in the province of Pinar del Rio.

Macromischa (Macromischa) fuscata, new species

WORKER.—Length 3 mm.

Head a little longer than broad, as broad in front as behind, with narrowly rounded corners and straight occipital border. Clypeus convex; anterior border straight. Eyes moderately convex, situated at middle of sides of head. Antennal scapes not attaining occipital corners; first funicular joint distinctly longer than the two succeeding joints together; terminal joint as long as the two preceding joints together. Thorax and epinotum rather slender; pronotum proportionately broader than in *flavitarisus*. Epinotal spines thick, longer than the declivity and rather strongly bent downward at apical third. Peduncle of petiole acutely toothed antero-ventrally, as long as the node, into which it slopes gradually; node longer than high, the anterior, dorsal and posterior surfaces broadly rounding into each other, from above as long as broad. Postpetiole one and a half times as broad as petiole, a little longer than broad and slightly narrower in front than behind, with moderately convex sides. Gaster ovate; sting fine. Femora moderately and tibiae scarcely swollen.

Shining. Mandibles striate. Head coarsely and very densely punctate throughout, with longitudinal, moderately dense and interrupted striae on vertex, front, cheeks and clypeus. Thorax and epinotum longitudinally, rugosely carinate. Petiolar node rugose. Postpetiole densely punctate. Gaster smooth. Legs and antennae finely and densely punctate.

Scattered, erect, stiff, and obtuse hairs present on head and body and finer, silky pubescence on legs and antennae.

Color very dark brown to black, gaster black, with deep blue lustre; tarsi brown.

Guatemala:—Antigua; December 1911; (W. M. Wheeler).

The elongate postpetiole and the structure of the petiolar node sharply distinguish *fuscata* from the other Central American species. The epinotal spines are unusually coarse and strongly curved. The species was taken in a hollow twig.

Macromischa (Macromischa) flavitaris, new species

WORKER.—Length 3 mm.

Head longer than broad, rectangular, with slightly convex sides and nearly straight posterior border. Mandibles stout, with five teeth. Clypeus with a strong median and two weaker lateral carinae, indistinctly concave at middle of anterior border. Eyes large and moderately convex, situated at middle of sides of head. Antennae slender, scapes not attaining occipital borders; first funicular joint as long as the two succeeding joints together; club slender; terminal joint as long as the two preceding joints together. Thorax stout, without sutures. Pronotum rounded at sides, little broader than mesonotum. Epinotal spines moderately thick, a little shorter than the peduncle of petiole, curved downward, somewhat angularly at middle. Petiole long and slender, its peduncle nearly three times as long as the node, with a short, stout tooth anteroventrally, node in profile twice as high as long, with abrupt anterior and posterior surfaces, narrowly rounded above; from above twice as broad as long, rounded in front and behind and narrowed at sides. Postpetiole a little broader than petiole, broader than long, with rounded sides. Femora slightly swollen, tibiae not enlarged. Sting long and powerful.

Moderately shining. Mandibles coarsely striate and punctate. Head with fine, interrupted and separated carinulae, parallel on front and vertex and curved on cheeks, and also irregularly punctate. Striation on thorax and epinotum delicate and sparse, with rather abundant though scattered punctures. Meso- and metapleuræ densely, but shallowly punctate. Petiole and postpetiole very finely punctate. Gaster with sparse, minute punctures. Legs and antennæ less shining than the rest and densely and shallowly punctate.

Hairs on head and body erect, stiff, obtuse, and sparse; those on antennæ and legs fine, silky and recumbent.

Color black; tarsi brownish yellow.

FEMALE.—Length 4-4.25 mm.

Epinotal spines shorter and stouter than in the worker, though longer than their distance apart at base. Petiolar node somewhat shorter and broader above when seen from the side. Mesonotum very densely and finely striate longitudinally.

Color black, with the outer border of tibiae and the tarsi brownish yellow.

Wings slightly infuscated. Veins and stigma brownish.

Guatemala:—Guatemala City; Antigua, December 1911; (W. M. Wheeler).

I have before me two females and a small series of workers from two colonies, one of them taken in a fence-post, the other in a hollow twig.

The amount of brown coloration on the outer edge of the tibiae varies. In the Antigua specimens it is stronger than in the others and very pronounced in the females.

Near *salvini* Forel and its variety *obscurior* Forel from Panama, but differing markedly in sculpture, the Panama forms having the thorax rugose and subopaque. The antennal scapes in *flavitorsus* do not extend to the occipital corners and in the related species they reach or extend beyond them.

***Macromischa (Cressomyrmex) versicolor* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 187, ♀.

WORKER.—Length 5-5½ mm.

Slender. Thorax and first petiolar segment light red, second joint, head and abdomen black, the latter also with blue lustre. Legs and antennæ dark reddish brown; mandibles and anterior margin of head more indistinctly so. White, stiff, erect hairs distributed over the body and appendages.

Head elongate oval, moderately narrowed posteriorly. Antennæ very slender, long, their scapes longer than the head, the two last funicular joints long and cylindrical, but still somewhat shorter than the remaining joints together. Frontal area triangular, acuminate posteriorly, the head resembling that of *Aphenogaster testaceopilosa*. Mandibles longitudinally rugose. Head not shining, very densely tuberculately or "thimble-like" punctate, on the sides in front of eyes longitudinally rugose.

Thorax somewhat arcuate at sides. Pronotum very little enlarged at middle, rest of thorax subequal in width. Epinotum behind obliquely truncate, unarmed. Thorax almost without lustre, "thimble-like," densely punctate and longitudinally with

separated flattened rugæ. Petiole red, somewhat blackish above, finely "thimble-like" punctate, long cylindrical and arcuate, the node small, the angular enlargement in middle of pedicel, when viewed from above is barely indicated; apparently without ventral tooth. Postpetiole bell-shaped, shining. Abdomen smooth and shining. Legs slender, shining, the femora very thin basally, then awl-shaped and thickened, but not as strongly as in *purpurata*, tibiæ not thickened. [Translation.]

A single worker from Cuba; (Roger).

Gundlach's locality is "Isle of Pines," in the farallones near Nueva Gerona.

***Macromischa (Cræsomymex) iris* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 188, ♀.

WORKER.—Length 5.5 mm.

Head green, with violet and blue reflections, not shining; thorax purple-violet with strong æneus reflection. Petiole yellowish brown, lobes and gaster as well as femora dark metallic green or brown, very shining, tibiæ, tarsi, and antennal funiculus lighter brown. Everywhere with erect, whitish pubescence.

Head rather broadly oval, densely "thimble-like" punctate. Clypeus transverse or arcuate in front, longitudinally rugose posteriorly; mandibles rugose longitudinally. Frontal area triangular, shining. Antennal fossæ small. Antennal scapes slender. Club three-jointed.

Pronotum very feebly arcuately widened at sides. Meso-epinotum somewhat compressed laterally, above feebly "roof-shaped." (Seen from above the thorax appears subequal in width throughout.) Epinotum posteriorly arcuately rounded, scarcely truncated, unarmed. The whole thorax is irregularly rugose above and longitudinally and very coarsely rugose at sides.

Petiole in front cylindrical, long, in the middle (when viewed from above), very feebly angular, posteriorly swollen into a moderately strong node; the ventral tooth appears to be absent. Postpetiole bell-shaped, both nodes smooth and shining. Abdomen smooth and shining. Femora strongly incrassate at middle; tibiæ not incrassate. [Translation.]

One worker from Cuba; (Roger).

This species was taken on the cliffs at the entrance to the Yumuri Valley at Matanzas. I searched unsuccessfully for it in the same locality.

***Macromischa (Cræsomymex) wheeleri*, new species**

WORKER.—Length 3.75–4 mm. (Fig. 6).

Head longer than broad, sides little convex, occipital corners very broadly rounded, border slightly convex. Mandibles with five rather stout teeth. Clypeus rounded; anterior border broadly and shallowly concave. Frontal carinæ short, only moderately divergent behind. Eyes situated at middle of sides of head. Antennæ slender, their scapes surpassing the occipital corners; first funicular joint a little longer than the two succeeding joints together, the joints gradually increasing in size to the slender club; first two joints of club subequal in length, terminal joint a little shorter than the two preceding joints together. Thorax two and a half times as long as broad. Prothorax as broad as long, with rounded sides and humeri. Base of epinotum

longer than the declivity, from which it is separated by an obtuse angle; sides subgibbous, but without spines; declivous surface flat. Peduncle of petiole somewhat curved, bluntly toothed beneath in front, about as long as the node, which in profile is longer than high and very broadly rounded above and, from above, twice as long as broad, with slightly convex sides. Postpetiole as long as the petiolar node; from above, three times as broad behind as in front and about as long as broad. Femora incrassated, tibiae very slightly so.

Body and appendages shining, postpetiole and gaster with sparse punctures; mandibles, clypeus, cheeks and scapes striate. Thorax and epinotum coarsely rugose, the rugæ tortuous on pronotum and transverse on meso- and epinotum. Petiole rugulose at sides.

Body and appendages with sparse stiff hairs.

Color brilliant metallic green; thorax and epinotum darker than the rest.

FEMALE (deälated).—Length 5 mm.

Epinotum armed with a pair of blunt spines, the rest similar to the worker, with the usual sexual modifications and the following differences in sculpture. Pronotum transversely rugose. Mesonotum in front rugulose, but with a nearly smooth surface at middle; posterior third more coarsely rugose. Scutellum rugose at sides, more finely above and with a smooth disc at middle. Epinotum transversely rugose.



Fig. 6. *Macromischa* (*Crasomyrmex*) *wheeleri* Mann, ♀. Thorax and petiole from side.

Cuba:—Mina Carlota (Trinidad Mts.).

This beautiful species is related to *porphyritis* and *iris*, but is much smaller than either of these, differently colored, and has the head smooth and very shining.

Described from a series of workers and females taken from several colonies. One colony was nesting in a block of limestone. I attempted to turn the stone over to search beneath it, when it split in two, disclosing the whole colony of about thirty workers and one deälated female with many larvæ and pupæ gathered in a little pocket. The other colonies were found in hollow twigs lying on the ground.

***Macromischa* (*Antillæmyrmex*) *terricola*, new species**

WORKER.—Length 1.50–1.75 mm. (Fig. 7).

Head rectangular, longer than broad, as broad in front as behind, with feebly convex sides and nearly straight occipital border. Mandibles with five small teeth. Clypeus convex, rounded at anterior border. Eyes at sides of head in front of middle. Antennæ short, not quite attaining occipital corners; first funicular joint stout, as long as the two succeeding joints together; remaining joints, except those of the

club, transverse; terminal joint of club distinctly longer than the two preceding joints together. Thorax robust, without sutures; sides of pronotum rounded; of meso- and epinotum subparallel. Epinotal spines a little longer than their distance apart at base, rather stout, divergent and curving slightly downward. Petiole a little more than twice as long as broad, peduncle stout, about as long as node, toothed antero-ventrally; node higher than long, broadly rounded above with declivous anterior and rounded posterior surfaces. Postpetiole more than three times broader than petiole and twice as broad as long, with rounded sides and straight anterior border. Gaster thick. Femora and tibiae moderately incrassate.

Body and appendages shining; thorax, epinotum, and petiole densely, rather coarsely but shallowly punctate and less shining than the rest. Mandibles subtilly striate. Head and gaster sparsely and finely punctate.

Head, thorax, and gaster with sparse, erect, blunt hairs; antennae and legs with fine pilosity, but no erect hairs.

Head, except anterior margin, and gaster dark brown to black; thorax, epinotum, petiole and postpetiole dark ferruginous; anterior margin of head, mandibles, antennae, and legs brownish yellow.



Fig. 7. *Machromischa (Antillemyrmea) terricola* Mann, ♀. Thorax and petiole from side.

FEMALE (deâlated).—Length 2.25 mm.

Epinotal spines very broad basally, curving downward at tips. Petiole shorter than in worker, with the node from above broader than long and truncate in front.

Shining. Mesonotum with dense longitudinal striae at middle; smooth at sides. Sides of scutellum and the epinotum densely punctate and less shining than the rest. Head, petiole, postpetiole and gaster as in worker.

Color black, thorax, epinotum, petiole and postpetiole slightly brownish; anterior border of head, the mandibles, antennae and legs brownish yellow.

Cuba:—Baracoa.

Described from individuals taken in a small colony beneath a stone in a pine forest near the village.

This species belongs in a group of small, ground-inhabiting forms, characterized by the more or less rectangular form of the head, the stoutly pedunculate petiole, and small size. *M. flavidula* from Hayti is a member of the group but distinct from the others, *albispina* and its variety *pallipes* from Porto Rico, *pulchella* from St. Thomas and *terricola*. These latter three are closely related and may be specifically identical. *M. albispina* is larger and very densely punctate and opaque; *pulchella* has the body shining but lacks the punctation on the thoracic dorsum. *M. terricola* appears to be intermediate between these two.

Crematogaster sanguinea Roger

ROGER, 1863, *Berliner ent. Zeitschr.*, VII, p. 208, ♂.

Cuba:—Herradura.

Several small workers taken on a fence-post have the basal portion of the first gastric segment red in color and are, for that reason, referred to the typical form of *sanguinea*.

Crematogaster sanguinea Roger variety **torrei** Wheeler

WHEELER, 1913, *Bull. Mus. Comp. Zool. Camb.*, LIV, p. 490, ♂, ♀.

Cuba:—Felton; Limones.

This variety differs from the preceding only in having the gaster entirely black.

Crematogaster sanguinea Roger **atavista**, new variety

Several workers from a colony found nesting in rotten wood are distinct in having the head, thorax, and abdomen entirely black. The legs and antennæ are very dark, except the tarsi and funicular club which are fuscous.

Cuba:—Yateras District.

Crematogaster sanguinea Roger **sotolongoi**, new subspecies

The thorax, instead of being rather strongly rugose, as in the typical form and its varieties, is smooth and very shining. The head and gaster are black; the thorax, petiole, postpetiole, and the appendages obscurely rufous.

Cuba:—Pinares. A small series of workers found beneath the bark of pine trees near the Woodfred Inn.

Crematogaster victima F. Smith **cubaensis**, new subspecies

WORKER.—Length 1.50–1.75 mm.

Head a little broader than long, as broad in front as behind, with convex sides and rounded occipital corners; border narrowly concave at middle, frontal area indistinct. Mandibles five-dentate. Antennæ stout, their scapes slightly surpassing occipital corners; first funicular joint as long as the two succeeding joints together; remaining joints, except those of club, broader than long; club slender, three-jointed; terminal joint three and a half times as long as broad and as long as the two preceding joints together. Eyes large and convex, situated at sides of head posterior to middle. Thorax strongly impressed at meso-epinotal suture. Epinotal spines straight, triangular and about half as long as their distance apart at base. Petiole longer than broad, a little broader behind than in front, with straight sides and flattened surfaces; in profile thick behind and gradually tapering anteriorly, less than twice as long as high. Postpetiole a little broader than the petiole; subglobose. Gaster broad, triangular and flattened above. Legs rather stout.

Shining. Epinotum, petiole and postpetiole microscopically punctate.

Head, body and appendages with sparse, coarse hairs, rather sparsely distributed.

Color yellow.

FEMALE.—Length 3 mm.

Similar to worker, with the usual sexual differences.

Cuba:—Guantanamo.

Described from one female and a small series of workers taken from beneath a stone in the woods.

This subspecies is distinct from *victima* var. *steinheili* Forel in its more robust structure, its more globose pronotum, in sculpture, and in color. The punctuation on the epinotum, petiole and postpetiole of *steinheili* is distinct, in *cubaensis* it is barely discernible.

***Pheidole cubaensis* Mayr *grayi*, new variety**

Several soldiers and workers from a colony found beneath a stone agree with Mayr's description except in colors. In the soldiers the head and body are black, only the clypeus being reddish brown. The mandibles and legs are brown. The workers are black, except the mandibles, antennæ, tibiæ, and tarsi which are brown.

Cuba:—Limonas.

The head of the typical form is described as red and, according to Wheeler, the single soldier in Gundlach's collection has the head red, so I am considering the series before me as distinct. A soldier in Wheeler's collection from Cayamas (Collector Schwarz) and noted by Wheeler (1913, Bull. Mus. Comp Zool. Camb. LIV, No. 17, p. 490), evidently belongs to this variety.

***Pheidole fallax* Mayr**

MAYR, 1870, Verh. zool.-bot. Ges. Wien, XX, pp. 980, 984, ♀.

Cuba:—Cienfuegos.

Cuba is the type locality for this species, but it has apparently not been previously taken on the island since Gundlach's time. My specimens were found on the railroad track near the station. They were nesting beneath the ties.

***Pheidole androsana* Wheeler**

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 90, ♂, ♀.

Bahamas:—Eleuthera.

A single colony from beneath a stone.

***Pheidole androsana* Wheeler subspecies *bakeri* Forel**

FOREL, 1912, Ent. mitt., I, p. 82, ♀, ♂.

Cuba:—Cardenas; San Blas.

One large colony was found in each locality. The type locality is Havana, so the species occurs throughout at least the eastern part of the island, though it is rare locally.

***Pheidole flavens* Roger**

ROGER, 1863, *Berliner, ent. Zeitschr.*, VII, p. 198, ♂, ♀.

Bahamas:—New Providence; Eleuthera.

Cuba:—Herradura; Limones.

***Pheidole flavens* Roger subspecies *asperithorax* Emery variety *semipolita*
Emery**

EMERY, 1896, *Bull. Soc. ent. Ital.*, XXVIII, p. 78, ♂, ♀.

Cuba:—Baracoa.

Several soldiers from a single colony agree perfectly with Emery's description of this variety from Para, Brazil.

***Pheidole flavens* Roger *asperithorax* Emery, variety ?**

Bahamas:—Andros.

A single colony of a variety close to, if not identical with, this subspecies.

***Pheidole punctatissima* Mayr subspecies *annectens* Wheeler**

WHEELER, 1905, *Bull. Amer. Mus. Nat. Hist.*, XXI, p. 93, ♂, ♀, ♀.

Bahamas:—New Providence (Nassau).

***Pheidole punctatissima* Mayr variety**

Cuba:—Mina Carlota; Pinares.

***Solenopsis geminata* Fabricius**

Atta geminata FABRICIUS, 1804, *Syst., Piez.*, p. 423, No. 6, ♀.

Distributed everywhere throughout Cuba and the Bahamas, where it is a decided pest, both on account of its sting and because it attacks the tender buds of plants, especially of citrus fruits, to which it does much harm. It is one of the species that are very fond of attending scale insects and, by protecting these, must cause, indirectly, considerable damage. Sometimes it lives in houses. At Guantanamo I got rid of a horde that was in my room at the hotel by leaving about honey mixed with a little Fowler's solution. The workers and soldiers ate it greedily as soon as they found it and during the week following no more were seen in the room.

***Solenopsis leviceps* Mayr**

MAYR, 1870, *Sitz. Akad. Wiss. Wien*, LXI, p. 406, ♀.

Bahamas:—New Providence (Nassau).

Several workers from a small colony that was nesting with *Wasmanina auropunctata* agree closely with Mayr's description of workers from Columbia.

***Solenopsis corticalis* Forel *binotata*, new variety**

Differing from the typical form in color and in its very sparse pilosity. The color is clear yellow, with distinct fuscous spots at the sides of the first gastric segment apically.

Cuba:—San Antonio de Sul.

The variety *virgula* Forel, also from Cuba, has the head shorter than in the typical St. Thomas form and in *binotatus*, but in the description no mention is made of the color.

***Solenopsis globularia* F. Smith *desecheensis*, new variety**

Two workers, collected by Frank E. Lutz, given to me by Prof. Wheeler belong to an undescribed variety of *globularia*, differing from the typical form and the variety *borinquensis* Wheeler in color. The head and body are jet black, with the antennæ and legs yellowish brown.

Desecheo Island, Porto Rico.

***Wasmannia auropunctata* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 182, ♀, ♀, ♂.

Cuba:—Viguitas (Oriente); Mina Carlota.

***Atta insularis* Guérin**

GUÉRIN, 1845, Iconogr. Regn. Anim., VII, Insect., p. 422, ♀.

Cuba:—Throughout the island.

With the possible exception of the black fly (*Aleurocanthus woglumi* Ashby), *Atta insularis* (known to the Cubans as "Bibijagua") is the most serious insect pest of the island. It gathers leaves from several species of plants, but chiefly from the tapioca ("Yuca") and citrus trees, especially the orange.

Solitary trees are sometimes protected by a double circle of tin at the base containing water (Fig. 8), a good protection where there are few trees. Small colonies may be exterminated by pouring carbon bisulphide in the burrows. Larger colonies are best destroyed by fumigation with sulphur fumes, forced into the nest entrance by a bellows. When this is thoroughly done it is an entirely satisfactory means of controlling the ant.

Acromyrmex (Trachymyrmex) jamaicensis* Ern. André variety**maritima* Wheeler**

Atta (Trachymyrmex) maritima WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 107, ♀.

Bahamas:—Andros (Mangrove Cay); Eleuthera (Bluff).

Large series from the two localities differ from typical *jamaicensis* in the uniformly darker color.



Fig. 8. Double pan, filled with water, at base of orange tree to protect it from the "bibijagua" (*Atta insularis* Guérin).

Mycocepurus smithi Forel variety **borinquenensis** Wheeler

WHEELER, 1907, Bull. Amer. Mus. Nat. Hist., XXIII, p. 718, ♀.

Cuba:—Limonas.

Cryptocerys (**Hypocryptocerys**) **hæmorrhoidalis** Latreille

LATREILLE, 1802, Hist. nat. fourmis, p. 276, ♀.

San Domingo:—Blanton Mine, north of San Cristobal; (Morrison)

Cryptocerys (**Cryptocerys**) **varians** F. Smith

SMITH, 1876, Trans. Ent. Soc. London, p. 606, ♀.

Bahamas:—New Providence (Nassau); Andros (Mangrove Cay).

Cuba:—San Antonio de los Baños; Cienfuegos (Quinta Cabada); Castillo; Yateras; Cardenas.

Strumigenys eggersi Emery **cubaensis**, new variety

A small series of workers differ from typical *eggersi* in not having the inner borders of the mandibles denticulate, in this respect resembling var. *vicentensis* Forel from St. Vincent, but the latter variety has the gaster smooth and shining, while in *cubaensis* it is opaque.

Cuba:—Cienfuegos.

Strumigenys rogeri Emery

Pyramica gundlachi ROGER, 1862, Berliner ent. Zeitschr., VII, pp. 253, 254, fig. 18a, ♀.

EMERY, 1890, Bull. Soc. ent. Ital., XXII, p. 31, Pl. VII, fig. 6, ♀.

Cuba:—Santiago de Cuba; Mina Carlota.

Several workers agree closely with Emery's description and figure of the worker of this species and with workers from Hayti. The single female before me undoubtedly is the same form that Roger described and figured as that of *Pyramica gundlachi*.

Strumigenys alberti Forel

FOREL, 1873, Trans. Ent. Soc. London, p. 380, ♀, ♀.

Cuba:—Santiago de Cuba; Baracoa; Mina Carlota; Yateras District; Cienfuegos; Limonas.

This is the commonest species of *Strumigenys* on the island. It nests beneath stones, bark, and among rotting leaves.

Strumigenys margaritæ Forel

FOREL, 1893, Trans. Ent. Soc. London, pp. 378-380, ♀, ♀, ♂.

Bahamas:—New Providence (Nassau).

Epitritus emmæ Emery

EMERY, 1890, Bull. Soc. ent. Ital., XXII, p. 70, Pl. VIII, fig. 6, ♀.

Bahamas:—Andros (Fresh Creek).

A single worker was found beneath a stone.

Dolichoderinæ**Tapinoma litorale** Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 109, ♀, ♀, ♂.

Bahamas:—Andros (Fresh Creek; Mangrove Cay).

Tapinoma litorale Wheeler variety **cubaensis** Wheeler

WHEELER, 1913, Bull. Mus. Comp. Zool. Camb., LIV, p. 498, ♀, ♀.

Cuba:—Mina Carlota; Guantanamo.

Dorymyrmex pyramicus Roger

Prenolepis pyramica ROGER, 1863, Berliner ent. Zeitschr., VII, p. 160, ♀.

Cuba:—Limonas.

Much less common than the following variety.

Dorymyrmex pyramicus Roger variety **niger** Pergande

PERGANDE, 1895, Proc. Cal. Acad. Sci., (2) V, p. 871, ♀.

Cuba:—Abundant throughout the island.

San Domingo:—Blanton Mine; Duarte; San Pedro de Macoris.

Camponotinæ**Brachymyrmex heeri** Forel variety **obscurior** Forel

FOREL, 1893, Trans. Ent. Soc. Lond., p. 345, ♀.

Cuba:—Cienfuegos; San Blas.

San Domingo:—San Domingo City; (Morrison).

Prenolepis (Nylanderia) vividula Nylander variety **antillana** Forel

Prenolepis guatemalensis subsp. *antillana* Forel, 1893, Trans. Ent. Soc. London, p. 340, ♀, ♀, ♂.

Cuba:—Guantanamo; Mina Carlota; Baracoa.

Prenolepis (Nylanderia) steinhelli Forel

FOREL, 1893, Trans. Ent. Soc. London, p. 324, ♀.

Cuba:—San Antonio de los Baños.

Prenolepis (Nylanderia) anthracina Roger

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 161, ♀.

Cuba:—Baracoa; Mina Carlota; Yateras District.

Several small colonies were found beneath stones, but no males were seen. The workers resemble those of *steinheili*, but have the head proportionately broader and more convex at sides and the color is much darker.

***Prenolepis (Nylanderia) myops*, new species**

WORKER.—Length 1.75 mm.

Head longer than broad, slightly narrowed in front, with nearly straight sides, broadly rounded corners and straight occipital border. Mandibles with four slender teeth. Clypeus twice as broad as long, strongly convex, narrowly concave at middle of anterior border. Antennal scapes surpassing the occipital corners by three-eighths of their length; first funicular joint a little shorter than the second and third together; terminal joint strongly compressed, about as long as the two preceding joints together. Eyes very small, composed of eight ommatidia, situated in front of sides and well anterior to middle. Pronotum longer than broad, flattened above. Mesonotum as broad as long, flattened. Epinotum rounded basally, the declivous portion flattened at middle obtusely margined and bituberculate at sides. Petiolar scale cuneiform, with the anterior surface flat and the posterior rounded; seen from behind, more than twice as high as broad, with nearly straight sides and rounded upper margin. Gaster stout, legs long and slender.

Smooth and shining, with erect hairs very coarse and moderately abundant on head and body and finer on appendages.

Color brownish yellow to lemon-yellow.

FEMALE (deälated).—Length 3.20 mm.

Differing from the worker in having the head as broad as long and with more convex sides. Mesonotum with strong lateral furrows. Scutellum much broader than long and flattened.

Front, vertex and occiput shallowly but densely punctate. Gastric segments densely striolate.

Hairs on head fine, silky and rather dense; elsewhere similar to those of worker.

Color brown; antennæ and legs yellowish brown.

MALE.—Length 1.50 mm.

Head, excluding eyes, a little longer than broad, convex at sides and straight behind. Vertex depressed between the ocelli; front with a strong impression beneath the median ocellus and another between the frontal carinæ. Mandibles well developed, edentate. Clypeus with straight anterior border. Eyes convex, about three times as long as their distance from anterior border of head. Antennal scapes attaining occipital corners; funicular joints one to five cylindrical, longer than broad; remaining joints compressed; terminal joint asymmetrically lanceolate, as long as the two preceding joints together. Thorax robust. Mesothorax flat in front, transversely impressed at apical third, without Mayrian furrows; parapsidal furrows narrow. Scutellum transverse, rounded. Base and declivity of epinotum rounding into each other. Petiolar scale small, thin and directed forward. Gaster large and stout; genitalia prominent; stipites large and spatulate apically, squamulæ convex and rounded apically.

Shining. Head and thorax densely, shallowly punctate. Without erect hairs. Legs, antennæ, and gaster with pollinose pubescence.

Black, appendages brown. Wings hyaline with veins and stigma brown.

Cuba:—Mina Carlota (Trinidad Mts.).

Described from a series taken beneath a stone. Distinct from related species in the very small size of the eyes as well as in color.

***Prenolepis (Prenolepis) gibberosa* Roger**

ROGER, 1863, *Berliner ent. Zeitschr.*, VII, p. 161, ♀.

WORKER.—Length 3–3.5 mm. (Fig. 9).

Head a little longer than broad, as broad in front as behind, with slightly convex sides, rounded corners and nearly straight occipital border. Mandibles slender, with five triangular teeth. Clypeus strongly convex, anterior border straight. Frontal carinae short, feeble, and parallel. Frontal area distinct, a little broader than long. Antennae long and slender, their scapes surpassing the occipital corners by two-thirds their length, slightly thickened at distal third; funicular joints one to seven about



Fig. 9. *Prenolepis (Prenolepis) gibberosa* Roger ♀. Head, thorax, and petiole from side.

four times as long as broad; joints eight to ten proportionately shorter than the two preceding joints together, longitudinally impressed at anterior two-thirds. Eyes small and convex, situated in front of sides of head, a little behind the middle. Thorax slender. Pronotum longer than broad, narrowed anteriorly. Mesothorax in profile saddle-shaped; from above, strongly constricted, a third as broad as the pronotum, with a pair of small tubercles posteriorly. Epinotum at base elevated into a rounded hump. Petiolar scale in profile directed forward, with straight anterior and posterior surfaces, little narrowed above and rounded. Gaster oval. Legs very long and slender.

Head and body microscopically, granulosely opaque. Gaster opaque, finely and densely punctate and with small setigerous tubercles. Legs densely and shallowly punctate.

Coarse, stiff, erect hairs sparsely distributed on head and body, and finer and shorter hairs on appendages.

Color brown, gaster black, apices of femora, bases of tibiae, tarsi, and apical half of antennal funiculi white.

Cuba:—Baracoa; Piedra Gorda; Pinares.

This form is apparently confined to the mountains of eastern Cuba, while the following subspecies occurs also in western localities.

Prenolepis (Prenolepis) gibberosa Roger rogeri, new subspecies

WORKER.—Length 4 mm.

Differing from the preceding form in its larger size more robust in form, in having the gaster shining instead of opaque and in color. The brown of the head, thorax, epinotum, and petiole is more reddish. The appendages are uniformly dark reddish brown, in some individuals almost black.

Cuba:—Yateras District; Guantanamo; San Blas (type locality).

Both *gibberosa* and its subspecies *rogeri* live in deep woods, where they form large colonies in decayed logs. The workers are exceedingly active and in habitus and behavior remind one of *Plagiolepis longipes* Jerdon.

Myrmelachista rogeri Ern. André

ANDRÉ, 1887, Rev. ent., VI, p. 288, ♀.

Cuba:—Saetia (Oriente.)

Several workers found on a tree trunk are referable to this species. The color is black with the anterior margin of the head and mandibles reddish and the antennæ and tarsi brown.

Myrmelachista rogeri Enr. André *rubriceps*, new variety

WORKER.—Length 1.75–2.5 mm.

Head a little longer than broad, as broad in front as behind, with slightly convex sides, broadly rounded occipital corners and shallowly concave border. Mandibles with four unequal teeth. Antennæ short, their scapes thickened at anterior half, extending two-thirds the distance to occipital corners; first funicular joint nearly as long as the three succeeding joints together; joints two to five very small, broader than long; club strong, three-jointed, the terminal joint longer than the other two together. Eyes small and flat, situated at middle of sides of head. Pronotum as long as broad, rounded above and at sides. Promesonotal impression distinct, but not deep. Mesonotum convex, a little broader than long. Meso-epinotal impression profound. Epinotum from above, longer than broad, with rounded sides, in profile rather flat with the basal portion a little longer than the declivity. Petiolar scale twice as high as thick, anterior face rounded, posterior face flat, upper border strongly excised at middle. Gaster large, nearly as long as the rest of body and head together, rather flat. Legs robust, especially the anterior ones, and somewhat compressed.

Shining throughout. Mandibles finely striate and punctate; the head and body smooth, except for widely separated and minute punctures which are very distinct and regular on head and antennal scapes and more minute and less discernible on the rest of the body.

Pilosity sparse and very fine; shorter and somewhat coarser on antennæ and legs.

Head, mandibles, and antennæ brownish red; the rest, excepting tarsi, black. Tarsi brown.

Cuba:—Pinares.

Described from numerous workers taken from the trunks of pine trees.

This variety is distinct from the typical form in color and somewhat larger size. The cleft in the upper border of the node is deeper than in the typical form, but this character is variable and I have only a small series of the latter to compare.

***Myrmelachista ambigua* Forel subspecies *ramulorum* Wheeler**

WHEELER, 1908, Bull. Amer. Mus. Nat. Hist., XXIV, p. 155, ♀, ♂.

Porto Rico:—Maricao; Mayaguez.

St. Thomas:—Charlotte Amalie; (Morrison).

***Camponotus (Myrmobrachys) planatus* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 146, ♀, ♂.

Cuba:—Occurs very abundantly through the island, where I found it in all localities visited, except in the vicinity of Pinares in the pine forest.

***Camponotus (Myrmoturba) santosi* Forel**

FOREL, 1908, Verh. zool.-bot. ges. Wien, LVIII, p. 408, ♀.

Cuba:—San Antonio de los Banos; San Blas; Baracoa; Pinares; Mina Carlota; Limones.

***Camponotus (Myrmoturba) ramulorum* Wheeler**

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 114, ♀, ♂.

Cuba:—Cienfuegos; Simpatia; Yateras District; San Blas; Cardenas; Victoria de las Tunas; Mina Carlota.

Camponotus (Myrmoturba) maculatus* (Fabr.) subspecies *lucayanus

Wheeler

WHEELER, 1905, Bull. Amer. Mus. Nat. Hist., XXI, p. 112, 3 ♂♂, ♀.

Bahamas:—Andros (Fresh Creek); Eleuthera (Bluff).

***Camponotus (Myrmeurynota) gilviventris* Roger**

ROGER, 1863, Berliner ent. Zeitschr., VII, p. 145, ♀.

WORKER MAJOR.—Length 7–7.5 mm.

Head slightly longer than broad, a little narrowed in front, with feebly convex sides, rather prominent and very narrowly rounded occipital corners and nearly straight border. Mandibles thick, with five strong, triangular teeth. Clypeus broader than long, with anterior border very shallowly concave at middle; surface convex at middle and shallowly depressed at sides anterior to middle. Frontal carinae strong, extending half the distance to occipital border. Frontal area triangular. Cheeks with a strong pit touching marginal suture of clypeus a little in front of middle. Eyes large and rather flat, situated in front of sides of head at posterior third. Antennal scapes arcuate, thickened distally, surpassing occipital corners by a distance equa-

to twice their thickness at apex; first funicular joint three times as long as broad; succeeding joints much longer than broad, becoming proportionately shorter and thicker apically; penultimate joint less than twice as long as broad; terminal joint a little less than twice the length of the penultimate. Prothorax much broader than long, strongly lamellate at sides, with prominent, narrowly rounded humeri; surface very slightly convex. Mesothorax transversely oval; sides narrowly rounded, surface flat. Basal portion of epinotum from above appearing as an elevated hump, somewhat triangular in outline; in profile rounded above and about a third as long as the declivity, from which it is separated by a rounded angle. Node in profile wedge-shaped; sides very thin, apical border strongly and broadly excised at middle, with the sides produced angulately. Gaster short, broad and thick.

Subopaque. Mandibles very coarsely punctate, somewhat shining. Head, pronotum, mesonotum, and base of epinotum evenly and very densely punctate; sides of basal portion of epinotum, the declivity and petiolar node regularly striate. Gaster opaque, finely and densely punctate.

Antennæ with fine silky appressed hairs and a few longer suberect ones at tips of scapes. Head, thorax, epinotum, node, and legs with erect, very coarse white setæ, which are strongest and form a crest on the margin of the node. Head, besides, with fine and recumbent white hairs. Gaster with moderately dense scale-like, oppressed hairs and scattered, erect pile, golden in color.

Color black, with anterior portion of head, mandibles, antennæ, and dorsum of gaster red, the latter, however, with a black blotch at middle of base of first segment and blackish basal margins to the other segments. Legs black, tarsi brownish.

WORKER MINOR.—Length 5.5–6.5 mm.

Closely resembling the worker major, except in the smaller size of the head and the more elongate and slender antennal scapes, which surpass the occipital corners by a distance equal to one-fourth their length.

Cuba:—Mina Carlota; Pinares.

Found in the deep woods in the mountains, where workers are seen foraging on leaves and tree trunks. The colonies are very large and nest in hollow twigs or in cavities of trees. One colony was found in a fern stalk, the other end of which was occupied by a flourishing colony of *C. (Colobopsis) sphaericus* Roger.

***Camponotus (Colobopsis) sphaericus* Roger**

Camponotus sphaericus ROGER, 1863, Berliner ent. Zeitschr., VII, p. 146, ♀.

WORKER MAJOR.—Length 7 mm. (Fig. 10).

Head a little longer than broad, slightly narrowed in front, sides nearly straight, occipital corners narrowly rounded, border moderately convex, anterior truncated portion twice as broad as long, strongly carinate at sides and posteriorly strongly depressed; anterior third of the sides less depressed. Mandibles very stout, four-dentate. Clypeus slightly longer than broad, strongly narrowed behind, convex at middle, depressed in front laterally, not carinate; anterior border moderately excised at middle. Frontal carinæ strong, arcuate, extending three-fourths the distance to posterior border. Front, between carinæ, strongly impressed, the impression margined behind with elevated ridge, which becomes feeble at middle and divided by a longitudinal carina at middle. Eyes flat, situated a little posterior to the middle of

the space between posterior border of head and the truncated portion. Antennal scapes strongly curved and flattened basally, thickened apically, surpassing the occipital corners by a distance equal to their diameter at tips; first funicular joint a little longer than the second; remaining joints gradually decreasing in length; terminal joint twice as long as penultimate. Thorax robust. Pronotum more than twice as broad as long, arcuate, separated from pleuræ by an indistinct, rounded margin. Mesonotum a little broader than long. Epinotum evenly rounded above, the declivous portion flattened. Petiole in profile thin, wedge-shaped. Gaster thick, short. Legs short; femora compressed.

Subopaque. Head and legs somewhat more shining than the rest. Head, body and appendages finely and very densely punctate, impressed portions of head densely rugulose; vertex with scattered foveolate punctures. Mandibles sparsely and rugosely punctate and with fine striæ.

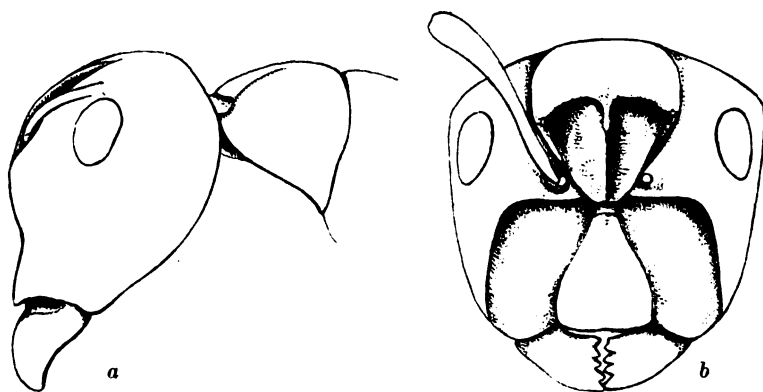


Fig. 10. *Camponotus (Colobopsis) sphericus* Roger, ♀. a.—Head and pronotum from side. b.—Head from front.

Vertex, thorax, epinotum, and gaster with abundant white, glistening hairs, erect on vertex and thorax, but both erect and recumbent on gaster. Legs with finer recumbent hairs. Antennal scapes with a few erect hairs at tips.

Color black, antennæ and legs red, the anterior femora infuscated on flexor sides. WORKER MINOR.—Length 5.5 mm.

Head longer than broad, narrowest in front, sides nearly straight. Clypeus broader than long, indistinctly and bluntly elevated at middle, with straight anterior border. Frontal carinæ feeble and short, not extending to opposite middle of eye. Antennæ slender, their scapes surpassing occipital corners by about one-third their length.

Body and appendages somewhat shining. Sculpture similar to that of soldier, except that the head is not rugulose in front and the erect white hairs are much more abundant and not absent on the front of head.

Co'lor as in worker, except the mandibles which are red instead of black.

Cuba:—Pinares Baracoa.

Redescribed from a large series which I found in a hollow fern stalk at Pinares and from specimens collected and given to me by Señor Patrucio Cardin, Government Entomologist of Cuba, who took them at Baracoa. The types of the species came from Santiago de Cuba. It apparently is a mountain form, confined to the eastern end of the island.

Camponotus (Colobopsis) sphaericus Roger cardini, new variety

Two workers collected by Frank E. Lutz and given to me by Prof. Wheeler differ from the preceding form in having all the femora black, except at the tips, and the pilosity of the gaster is rather more abundant.

Cuba:—North of Viñales.

Camponotus (Colobopsis) sphaericus Roger subspecies **sphaeralis** Roger
Camponotus sphaeralis ROGER, 1863, Berliner ent. Zeitschr., VII, p. 147, ♀.

SOLDIER.—Length 5 mm.

Differing from typical *sphaericus* in its smaller size and in the following characters: the pro- and mesothorax are longer in proportion to their width; the erect hairs on the body are sparser, the oppressed ones on the gaster are decidedly squamiform.

WORKER.—Length 4–4.5 mm.

Head proportionately a little longer than in *sphaericus*. Head and body beset with abundant, though not dense, squamiform white hairs. Erect pile much less abundant than in the typical form.

Cuba:—Cardenas; Victoria de las Tunas.

This and the preceding form, though distinct, are no more than sub-specifically different. The typical form is mountain inhabiting, living in the dense woods in hollow twigs. The subspecies occurs at lower altitudes and in dry open woods.

Camponotus (Colobopsis) gundlachi, new species

WORKER.—Length 3 mm.

Head a little longer than broad, with convex sides, rounded corners and convex occipital border. Mandibles with four elongate triangular teeth. Clypeus convex, obtusely carinate at middle, rounded in front. Antennæ slender, their scapes surpassing occipital corners by about one-third of their length; first funicular joint less than twice as long as the second; remaining joints subequal; terminal joint not as long as the two preceding joints together. Eyes large and convex, situated in front of sides of head and posterior to the middle. Pronotum about twice as broad as long, roundly margined at front and at anterior two-thirds of sides; the surface rather flat. Pro-mesonotal impression feeble; meso-epinotal impression obsolete above. Mesonotum twice as long as broad. Basal and declivous portions of epinotum rounding into each other, the surface of the latter flat, with rather prominent lateral tubercles. Petiolar node in profile a little more than twice as high as long, rounded in front, behind and above; margined at sides. Gaster small and elongate.

Shining throughout. Mandibles with dense and fine punctation and sparse, coarser punctures. Head and thorax above very densely, evenly and shallowly punctate; thoracic pleuræ, epinotum, petiole, and gaster subtilly striolate. Legs punctate.

tate similarly to body, but rather more fully.

Hairs on head and body very sparse, fine, silky and semirecumbent, those on antennæ and legs short and stiff.

Black, with the anterior portions of head and the mandibles reddish. Antennæ and legs yellowish brown.

Cuba:—*Saetia* (Oriente).

Described from a single worker taken on a leaf in dry open woods. I do not hesitate to describe the species from the worker phase, because it is undoubtedly a *Colobopsis* and strikingly different from any of the other West Indian species.

***Camponotus* (*Colobopsis*) *culmicola* Wheeler *haweisi*, new variety**

Distinguished from typical *culmicola* as follows. In the soldier the head is red, the remainder testaceous to brownish, with the last two gastric segments black. The workers are similarly colored, except that the head is light brown, similar to the thorax. The structure and sculpture are as in *culmicola*.

A soldier and small series from a colony taken in a hollow stalk at Nassau, Bahamas.

This very handsome variety is named after Mr. Stephen Haweis, the artist.

Article IX.—TWO NEW BATRACHIANS FROM COLOMBIA

BY G. K. NOBLE

In an earlier paper¹ I have indicated that a number of valuable collections of reptiles and amphibians from South America have been acquired in recent years by The American Museum of Natural History. The collection of amphibians from near Mesopotamia, Department of Antioquia, Colombia, presented to the American Museum by Mr. R. D. O. Johnson contains two new species of batrachians in addition to those species discussed in the earlier paper. I have selected one of these species as the type of a new genus, very distinct from *Hylella* with which it has hitherto been confused. *Hylella* has for a long time been recognized as an assemblage of unrelated species of specialized *Hyla*. But it is obvious from the following that all the species of *Hylella* cannot be indiscriminately referred to *Hyla*.

***Centrolenella*, new genus (Leptodactylidæ)**

DESCRIPTION.—Closely related to *Centrolene*, from which it differs in the absence of vomerine teeth and humeral spines; no omosternum; sternum narrow, cartilaginous; sacral diapophyses moderately dilated; fingers and toes webbed; outer metatarsals united; tips of the digits dilated into adhesive disks which are truncate or sub-truncate distally; pupil horizontal; tympanum exposed; tongue slightly notched, scarcely free behind.

TYPE.—*Centrolenella antioquiensis*, new species.

REMARKS.—*Centrolenella* bears nearly the same relations to *Centrolene* that *Hylella* does to *Hyla*. Still, it is more than a *Centrolene* which has lost the vomerine teeth. The Johnson collection contains a large female *Centrolene geckoideum* (A. M. N. H. No. 1383) from Santa Rita Creek. This specimen is 57 mm. in length, and has its ovaries well developed. It possesses the large humeral spines hitherto considered characteristic of the male. It, therefore, seems highly improbable that these humeral spines have any copulatory significance. From their position and form it seems more probable that they have some scansorial function, perhaps enabling the frog to retain its hold on a tree. *Centrolenella* lacks these humeral spines in the adults of both sexes.

¹Noble, 1917, Bull. Amer. Mus. Nat. Hist., XXXVII, pp. 793-814, Pls. xciii-xcvi. Through error one of the captions on p. 796 was repeated. The caption for drawing A of figure 1 should read *Eleutherodactylus martinicensis* in place of *Leptodactylus lineatus*. Typographical errors occur in the spelling of *Leptodactylus melanotus* on pages 795 and 796, of *Hylodes anomotus* on page 806, and of *Leptodactylus mystaceus* on page 812.

Hyla prosoblepon, described by Boettger (1892, Kat. Batr. Senck. Mus., p. 45) from Costa Rica, possesses so many external features in common with *Centrolene* that one is inclined to refer it to that genus. Still, the humeral spine of *H. prosoblepon* was described as peculiar to the male only, and the vomerine teeth may or may not be present as in many species of *Hyla*. Without an examination of its internal structure, the true relationships of *H. prosoblepon* cannot be determined with any degree of certainty.

It seems very probable that *Centrolenella* will be shown to embrace a number of species usually referred to *Hylella*. *C. antioquiensis*, as stated below, stands intermediate between *H. ocellata* and *H. parambae*. It seems probable that both these species will be shown referable to *Centrolenella*. I have examined a specimen (M. C. Z. No. 2526) of *Hylella buckleyi* in the Museum of Comparative Zoology collected by Rosenberg in Ecuador and probably identified by Boulenger as that species. It agrees entirely with his original description and figure (Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 420, Pl. xxv, fig. 5). This specimen was found on dissection to be a *Centrolenella*. *H. buckleyi* must be referred to that genus.

The question immediately arises whether the type species of *Hylella* possesses the T-shaped terminal phalanges and other features characterizing *Centrolenella*. If so, the name *Hylella* would have priority, but it would have to be restricted to a limited group of species. No specimens of *H. tenera*, the type species, are available for study but every indication points toward the conclusion that it is a *Hyla* which has failed to develop the vomerine teeth, as in the case of many other species of *Hyla*. The vertical loreal region, the distinct canthus rostralis, the type of color pattern, —all suggest the relationship of *H. tenera* to the genus *Hyla*.

An equally important argument, perhaps, is the fact that *Centrolenella antioquiensis* and *C. buckleyi*, as well as their apparently closest allies, are confined to the northern Andes just as is *Centrolene* from which this group of species seems to have evolved. *H. tenera* is a Brazilian species probably most closely related to certain Brazilian species of *Hylella* or *Hyla*. It seems extremely unlikely that *H. tenera* is a *Centrolenella*.

The relationship of *Centrolenella* to *Centrolene* is obvious, but the relationship of these two genera to any other is obscure. *Centrolene* was placed in the Leptodactylidæ by Boulenger (1882) but it has its sacral diapophyses expanded as much as the majority of hylids. If we search for the relationships of *Centrolene* among the Leptodactylidæ, we

find that it differs radically from all neotropical leptodactylids in lacking an omosternum and in possessing moderately expanded sacral diapophyses. The mere tabulation of its characters in general use in classification would show that it has most in common with the South African *Heleophryne*. But it differs from that genus in possessing an intercalary bone (or partly ossified cartilage) between the two terminal phalanges, in having its outer metatarsals bound together, and in exhibiting a narrow sternum, horizontal pupil, and webbed fingers. The several Australian-New Guinean genera of leptodactylids lacking the omosternum and possessing moderately dilated sacral diapophyses have little more in common with *Centrolene* than has *Heleophryne*. *Centrolene* seems to be an aberrant genus not closely allied to any of the known leptodactylids but possessing, perhaps through convergence, more features of certain Australian—South African genera than any neotropical.

So far as the characters used at the present time in batrachian classification would indicate, *Centrolene* and *Centrolenella* cannot be properly assigned to any of the existing families. They stand midway between the Leptodactylidæ and Hylidæ. In the paper mentioned above I have discussed in some detail the relationships of *Hyloscirtus*, a leptodactylid with claw-shaped terminal phalanges. If we should again attribute primary importance to the form of the sacral diapophyses, we might consider *Centrolene* and *Centrolenella* as hylids with T-shaped terminal phalanges. It is then obvious that all distinction between the Hylidæ and Leptodactylidæ breaks down.

There is some doubt as to how much emphasis should be laid on the form of the sacral diapophyses. Fry (1915, Proc. Queensland Roy. Soc., XXVII, p. 75, figs. 2a-2c) has shown that the distinction between the pelobatid *Lechriodus* and the leptodactylids *Chiroleptes* and *Heleioporus* is an artificial one, since their sacral diapophyses are nearly equally expanded. The sacral diapophyses of *Centrolene* are dilated about as much as those of *Heleioporus* (idem, fig. 2b). It seems most advisable to regard *Centrolene* and *Centrolenella* as leptodactylids which have developed expanded sacral diapophyses. These sacral diapophyses are not less expanded than those of several species of *Hyla* and several genera of hylids. The limits of the families Hylidæ and Leptodactylidæ grade into each other. Whether or not it is advisable to combine these two families is a matter of opinion, especially in view of the present unsatisfactory state of the classification of the Salientia.

Centrolenella antioquiensis, new species

DIAGNOSTIC CHARACTERS.—Canthus rostralis very rounded, the eyes directed partially forward; inner finger distinctly longer than the second, two outer fingers one-half webbed; toes nearly completely webbed; tibio-tarsal articulation extending a little beyond the snout; bluish gray above spotted with white.

DISTRIBUTION.—Known only from the type locality.

TYPE.—A. M. N. H. No. 1354 from Santa Rita Creek, fourteen miles north of village of Mesopotamia, in the southern part of the Department of Antioquia, Colombia; R. D. O. Johnson, collector.

DESCRIPTION OF TYPE.—(Adult female.) Tongue nearly circular, slightly notched behind; head about as long as broad, semicircular as seen from above; eyes directed partly forward, their greatest length equal to their distance from the end of the snout; canthus rostralis rounded off, not distinct; loreal region gradually sloping to the edge of the mouth; the two nostrils raised a little above the gradual slope of the snout; interorbital space one and a half times as wide as the width of the upper eyelid; tympanum distinct, one-third or one-fourth the greatest diameter of the eye. Fingers long, the first distinctly longer than the second, digital expansions about a fourth wider than the digits, squarely truncated, giving certain of the digital expansions a sub-triangular form; two outer fingers half webbed, the web extending to the base of the penultimate phalanx of the outer finger and to the distal third of the antepenultimate of the third finger; two inner fingers webbed only at the base; toes webbed to the digital expansions except the fourth which is webbed to the base of the penultimate phalanx; a single, inner metatarsal tubercle; subarticular tubercles small, not distinct; no tarsal fold or spur. Tibio-tarsal articulation extending a little beyond the end of the snout; tibia contained one and two-thirds times in the head and body length; upper surfaces smooth, belly and ventral surfaces of the thighs granular, no distinct fold across the chest.

Color above a bluish or purplish gray; about twenty whitish spots scattered widely over the dorsal surfaces; ventral surface including the concealed portions of the thighs a uniform yellowish white.

Dimensions

Tip of snout to vent.....	22 mm.
Width of head.....	8 "
Length of limb from axilla.....	12 "
Hind limb from vent to top of longest toe.....	38 "

NOTES ON PARATYPES.—In addition to the type we have an adult male, A. M. N. H. No. 1353, 20 mm. in length, and an immature specimen, A. M. N. H. No. 1356, 14 mm. long, both from the same locality as the type. The white dorsal spots of these two paratypes are not so numerous as in the type and the ground tone of the male is lighter. The general body proportions of all three specimens are identical.

RELATIONS.—*C. antioquiensis* appears to be intermediate between the two species described by Boulenger as *Hylella parambae* and *H. ocellata* respectively. The half-webbed outer fingers, long inner finger, and special coloration distinguishes *C. antioquiensis* from these species.

C. antioquiensis and *C. buckleyi* have the rounded snout, flat head, anteriorly directed eyes, truncate digits, and small tympanum of *Centrolene*. A number of species of *Hylella* have been described from the Andes and southern Central America with similar features. Future work will probably show that many, if not all, are referable to *Centrolenella*.

***Bufo rostratus*, new species**

DIAGNOSTIC CHARACTERS.—Crown of the head with or without projecting ridges; snout produced into a three-edged rostrum; paratoid glands triangular, not longer than the greatest diameter of the eye; tympanum hidden; fingers one-third, toes three-fourths webbed; no tarsal fold; skin tubercular above; a prominent series of large tubercles along each side of the back.

DISTRIBUTION.—Known only from the type locality.

TYPE.—A. M. N. H. No. 1359, from Santa Rita Creek, fourteen miles north of the village of Mesopotamia in the southern part of the Department of Antioquia, Colombia; R. D. O. Johnson, collector.

DESCRIPTION OF TYPE SPECIMEN.—(Adult male.) Head pointed, the snout produced into a rostrum which projects beyond the mouth for a distance equal to three-fourths the diameter of the eye; this rostrum flat above, the sides approaching each other to form a sharp ventral edge; distance from the angle of the jaw to the tip of the rostrum exactly equal to the greatest width of the head, one-third the head and body length; canthus rostralis very sharp, loreal region concave; inter-orbital space twice as wide as the width of the upper eyelid; dorsal surface of head tubercular but no cranial ridges apparent except for a short temporal crest extending from the posterior border of the eye to the paratoid gland; tympanum hidden; paratoid glands small, sub-triangular, about equal to the greatest diameter of the eye. Fingers long, webbed only a little beyond the metacarpals, but the web extending into the metacarpal region making the fingers appear about one-third webbed, the web continued along the edges of the fingers as a narrow seam; first finger about half as long as the second, in other words, extending only slightly beyond the metacarpal of the second finger; toes about three-fourths webbed, the web extending to the end of the last phalanx of the two inner toes, to the base of the last phalanx of the third and fifth toes, and to the base of the antepenultimate of the fourth toe; web continued as a seam to the tips of all the toes; two metatarsal tubercles, the inner much the larger; subarticular tubercles indistinct; no tarsal fold. Tibio-tarsal articulation extending only to the anterior end of the paratoid gland; tibia contained two and one-half times in the head and body length; skin of the back tubercular, a series of large tubercles forming a well-marked dorsolateral denticulated ridge; other large tubercles scattered over the back and dorsal surface of the appendages.

Color above yellowish brown, indistinctly marked with darker brown, forming crossbands on the legs; ventral surfaces yellowish white reticulated with dark brown.

Dimensions

Tip of snout to vent.....	41 mm.
Width of head.....	14 "
Length of fore limb from axilla.....	31 "
Hind limb from vent to tip of longest toe.....	51 "

NOTES ON PARATYPES.—Two other specimens, A. M. N. H. Nos. 1384, 1362, complete our series of the species. They come from the same locality as the type but they are apparently immature for they measure only 36 mm. and 23 mm. respectively. The larger of these two specimens differs radically from the type in having the skin of the skull involved in cranial ossification and produced in a series of ridges. The canthus rostralis is very sharp in this specimen and is continued posteriorly as a supraciliary ridge to the posterior border of the eye where it divides into two ridges, one continued posteriorly to the occipital region and the other extending outward along the posterior border of the orbit until it joins the short temporal ridge described in the type. This series of cranial ridges is very similar to that found in *B. coniferus* but here it does not form a specific nor, so far as I have been able to determine, even a sexual character. The three specimens of our series show a little variation in the distribution of the dorsal tubercles. Further, the two paratypes are redder, less yellow, than the type.

RELATIONS.—*B. rostratus* is apparently most closely related to *B. coniferus* Cope, which ranges from Nicaragua to Colombia. It agrees with that species in the formation of the cranial ridges (when present), in the short first finger, the dorsolateral series of tubercles, and small parotoid glands. It differs from *B. coniferus* in its greatly produced snout, hidden tympanum, and more extensively webbed digits. It is noteworthy that *B. rostratus* simulates several species of *Atelopus* in general form, agreeing especially well with *A. festæ* Peracca of Ecuador.

Article X.—NOTES ON AMERICAN LEPIDOPTERA WITH DESCRIPTIONS OF NEW VARIETIES

BY FRANK E. WATSON AND WM. P. COMSTOCK

Variation is a subject fruitful of discussion and, as all the butterflies described in the following pages are variations of recognized species, it seems best to make our position clear and define our terms, so that readers, who have not seen the works quoted below,¹ may have a clear understanding of just what we mean and what we consider these butterflies to be biologically and how we place them taxonomically. We follow the principles and nomenclature used by Rothschild and Jordan in their comprehensive revisions of the Sphingidæ and American Papilios.

We consider a "species" to be a group of individuals of the same general kind which are fertile *inter se* but which are or tend to be infertile with individuals of any other group. Every individual of a species possesses certain characters common to every other individual of the same sex of that species, except where there is "alternation of generations" or something of the sort, and these characters or their combination is not possessed by any other species. There may be little or great variation of characters within a species and the geographic range of a species may be large or small; or, as Rothschild and Jordan put it (Nov. Zool., XIII, p. 430, footnote) "The principal criterion of the conception 'species' is that species can exist together without fusing, no other barrier keeping them apart than their own organization."

We sometimes find one or several individuals which differ in one or more characters from other individuals of the species. If such variant individuals are rare, we consider them to be "aberrations" and, if they are quite distinct, we think it is well to call attention to them and to give them a name which may enable workers to refer to them without repeating a description. It is presumed but, without breeding experiments, cannot be positively asserted that the variant characters of an aberration are transmitted to its descendants although, if recessive in a Mendelian sense, they may not become evident again for many genera-

¹Rothschild, Walter and Jordan, Karl. 1903. A Revision of the Lepidopterous Family Sphingidæ. Nov. Zool., IX, Suppl.

Rothschild, Walter and Jordan, Karl. 1906. A Revision of the American Papilios. Nov. Zool., XIII.

Turner, Hy. J. 1913. The Terminology of Variation. Ent. Rec., XXV, pp. 230-233, 303, 304.
McAtee, W. L. 1920. Specific, Subspecific and Varietal Categories of Insects and the Naming of them. Ent. News, XXXI, pp. 46-55, 61-65.

tions, if at all. On the other hand, there may be such an increase in the number of individuals showing the aberrational characters that they are common in one or more localities. We consider that the aberration has then developed into a color phase or "form."

According to this conception, there is no fundamental difference between a form and an aberration. It is merely a question of the number of individuals showing the characters in question. What is now an aberration may become a form in a few years and what is merely an aberration in one locality may be abundant enough in another locality to be considered a form. In the latter case we would call it a form wherever found. We use the two terms merely to express the state of affairs at the present time as far as we know them.

A "subspecies" is a taxonomic division intermediate in rank between form and species and, as we use the term, two subspecies never occur in the same locality. They are incipient species. A subspecies might be considered to be a variety which has become so thoroughly established as to have replaced its ancestral form. If a species has broken up into subspecies or forms, or into both subspecies and forms, the species is the aggregate of all its varieties.

We consider "race," "geographical race" or "geographical variety" as synonymous with subspecies. When the term "form" is used in a definite, technical sense, we apply it to color forms or phases as before mentioned. As we are not dealing, in this paper, with either dimorphs or seasonal forms, we refer the student to the 'Monograph of the Sphingidæ,' p. xlv, for the proper formulæ. We do not use the word "variety" in any strict or definite sense but only as a general term to cover any or all of the various components of a species. The reasons for not using "variety" for a definite form are amply discussed in both of the revisions referred to above.

The taxonomic arrangement employed is to use a binomial for the species, if no subspecies be known. If subspecies are known a trinomial is used. These may be followed by the names for the form or aberration preceded by the abbreviations f. or ab. The name of an insect thus becomes a formula which shows at a glance its phylogenetic relationship, as understood by the author. We have employed the above defined system in arranging the following species and where our information warrants it in connection with previously described insects, we have changed the author's original designation.

***Basilarchia floridensis* ab. *halli*, new aberration**

This aberration differs from the typical *floridensis* of Strecker in having the extradiscal band on the secondaries above obsolete. All other markings above and below are as in the typical form. It is the same type of aberration as *B. archippus* ab. *lanthanis* Cook and Watson and if there be anything in the mimicry theory, it is a better mimic of *Danaus berenice* Cramer than is typical *floridensis* (Strecker).

Holotype male.—Florida; in The American Museum of Natural History. This specimen is in very fair condition except for a nick at the apex of the left secondary. Mr. G. C. Hall donated this specimen, which was purchased from a dealer, to the Museum and we take pleasure in dedicating it to him.

***Strymon acadica souhegan* (Whitney)**

W. H. Edwards described *acadica* in 1862 from a specimen taken by W. Saunders at London, Ontario. C. P. Whitney described *souhegan* in 1868 from specimens taken by him at Milford, New Hampshire, on the banks of the Souhegan River. W. H. Edwards lists *souhegan* as a variety of *acadica* (Synopsis of North American Butterflies, 1872, p. 29). Since that date *souhegan* has appeared in the synonymy in our various catalogues and there has been no recognition of its true significance.

A recent series of *acadica* received from Gravenhurst, Muskoka District, Ontario, collected by H. S. Parrish, were of such different appearance from the specimens of local capture in the hills of New Jersey that an investigation was prompted. These Muskoka specimens were captured July 19 to 27, 1918 and are in fresh and perfect condition. They agree very closely with W. H. Edward's original description of *acadica* and also with his figures (The Butterflies of North America, 1868, I, Pl. 1. *Thecla*). They were captured approximately 150 miles from London, Ontario. These specimens are characterized on the wings above by the dark ground-color, a slate-brown, the generally brownish fringes of the wings and the orange-red color of the spot between the tails. Beneath, the wings are a pearly brown with the maculation of usual form except that the orange-red markings are heavy and have a tendency to extend up on to the primaries more or less prominently.

A series of bred specimens from Hewitt, New Jersey, corresponds with the original description of *souhegan*. They are characterized above by the pale brown ground-color of the primaries, the generally whitish fringes of the wings and the orange color of the spot between the tails.

Beneath, the wings are a pearl gray color with the orange markings generally not so pronounced or of so reddish a color as true *acadica* and not so much extended on the primaries. The extradiscal rows of spots beneath are generally farther removed from the margin than in *acadica* and the row on the primary is generally bent in toward the base as it nears the costa to a greater extent than in *acadica*.

A comparison of the male genitalia of specimens from Gravenhurst, Hewitt, and Chilson Lake, Adirondack Mountains, Essex County, New York, shows minor differences. The Chilson Lake specimens are intermediate in wing appearance between typical *acadica* and *souhegan*. From the evidence presented it would seem that a resurrection of the name *souhegan* was warranted.

True *acadica* is represented only from the Muskoka locality in the collections before us.

The distribution of the *souhegan* race is shown by specimens from Hewitt, New Jersey; Ulster County and Van Cortlandt Park, New York.

Intergrades appear from Greene County and Chilson Lake, Adirondack Mountains, Essex County, New York.

***Strymon acadica acadica* ab. *muskoka*, new aberration**

This aberration differs from typical *acadica* on the upper side, in that the spot between the tails of the secondaries is pale orange instead of orange-red. Beneath, it varies from normal specimens in that the ordinarily orange-red markings are yellow. The character of separation is very distinct and is not due to fading, as the specimen is fresh and perfect and was received in a series of typical *acadica*. In the type specimen there is a general reduction in the size of all markings beneath but all are present; however, this may be considered as a note on the individual specimen only and not as a characterization of the aberration.

Holotype male.—Gravenhurst, Muskoka District, Ontario, Canada, July 27, 1918, (H. S. Parrish); in The American Museum of Natural History.

***Strymon acadica souhegan* ab. *swetti*, new aberration**

This aberration differs from typical *souhegan* (Whitney) on the under side only, the upper side being normal. The under side is similar to the typical form in the presence and location of all the usual markings. The difference lies in the ground-color, which is grayish white instead of the typical pearly gray. The black spots do not appear to be encircled with white as in normal specimens. This effect is produced by the lack

of contrast between the whitish ground-color and the white scaling around the spots. A slight trace of the normal ground-color is retained in the extreme outer margin of all wings between the submarginal lunules and the outer border; but this should be considered as an individual rather than a character difference.

Holotype male.—Stony Clove, Greene County, New York, altitude 1500 to 2000 feet, July 10, 1911, (F. E. Watson); in the collection of Wm. P. Comstock. We take pleasure in naming this aberration for Mr. L. W. Swett.

Strymon acadica coolinensis, new subspecies

This differs from true *acadica* in its larger size and paler coloration. Above, the wings both in the male and female are of the same color as *souhegan*; beneath, the ground-color is slightly darker than *souhegan* but lighter than typical *acadica*. The orange markings are a dull orange and not orange-red as in *acadica*. They come closer in color to *souhegan* but are not so bright. Compared to *souhegan*, which superficially it resembles more closely than *acadica*, it will be noted that the extradiscal rows of spots beneath are slightly closer to the margin of the wings as is the case in true *acadica*. The wing expanse is from 36 to 40 mm.,¹ averaging larger than any other race of *acadica* with which we are familiar. An examination of the male genitalia showed slight differences.

Holotype male and allotype.—Coolin, Idaho; in the collection of Wm. P. Comstock.

Paratype male,—Idaho; from the collection of Wm. P. Comstock and deposited in The American Museum of Natural History.

Strymon acadica montanensis, new subspecies

This is indistinguishable from *souhegan* on the upper surface but averages slightly larger, being from 36 to 38 mm. in expanse. Beneath, the ground-color is a pale but warm brown, several shades lighter than *acadica* and darker and different from the pearly gray color of *souhegan*. Moreover the extra discal row of spots on the primaries is arranged in a straighter line than in any of the other forms and does not curve in as much toward the base below the costal margin as in any of the other races. The male genitalia also shows differences.

Holotype male, allotype, and paratype male No. 3.—Montana; in The American Museum of Natural History.

Paratype males Nos. 1 and 2.—Montana; in the collection of Wm. P. Comstock.

¹All measurements are taken from center of thorax to apices.

***Strymon sœpium chlorophora*, new subspecies**

The male is dark red-brown with purplish reflections upon the upper side, *sœpium* (Boisduval) being of a slightly paler shade and not showing the purplish tinge. The purplish appearance is not dissimilar to that of the males of *Tharsalea virginiensis* (Edwards). Otherwise the upper side is as in *sœpium*. Beneath, the wings are of a dark purplish brown much darker than *sœpium* and presenting a strikingly different appearance. The extra discal line of both wings is present but all white markings, so noticeable a character in *sœpium*, are obsolete in some to absent in many individuals. The submarginal markings are not much fainter than in *sœpium* except at anal angle of secondaries, where they are much more reduced in prominence and only traces of white scales in and about the fringes remain. The blue anal patch is also reduced. There is a tendency more or less developed in individuals to a darker ground shading of brown within the extra discal lines. This is not at all characteristic of *sœpium*. The female is similar to the male except in that it is less distinguishable from *sœpium* female above.

Holotype male and allotype.—San Diego, California, June 14, 1913, (W. S. Wright); in the collection of Wm. P. Comstock.

Paratypes.—Sixteen males and seven females from the collections of Wm. P. Comstock and The American Museum of Natural History, where paratypes Nos. 1 and 2 are deposited.

***Strymon sœpium provo*, new subspecies**

The male is of a little paler brown above than *sœpium* but otherwise similar. Beneath, it is paler, being gray-brown varying in shade in different individuals. The underside markings are all present but reduced and in most specimens there is a slight development of the white scales which border the extradiscal spots in *sœpium* so prominently. There is no difference in the ground-color within and without the extradiscal rows of spots except to a slight extent in occasional individuals. The female is similar to the male.

Holotype male and allotype.—Provo, Utah, July 9, 1909, (T. Spalding); in the collection of Wm. P. Comstock.

Paratypes.—Eleven males and eleven females. Nos. 1, 2, 5, 6, 7, 8, 9, 10, from the collection of Wm. P. Comstock, are deposited in The American Museum of Natural History.

In comment on *Strymon sœpium*, the typical insect seems to be rare in collections. Boisduval very correctly characterized it ("Dessous brun,—traversé un peu au-delà du milieu par une petite ligne blanche")

and Oberthur has splendidly figured it (*Études de Lépidoptérologie Comparée*, 1913, IX, part 1, p. 40, Pl. ccxxxv, fig. 1922).

The form *fulvescens* (Henry Edwards) is also uncommon in collections. The types in the American Museum collection show it to be pale with the under side markings obsolete. The distribution of these two forms is not known beyond the type localities, but typical *chlorophora* is found also in Truckee, California and Medford, Oregon, and *provo* comes from Verdi, Nevada as well as the type locality. *Strymon chalcis* (Behr) seems to be well worthy of its name as it is distinct and, for the present at least, it does not seem advisable to drop it from specific rank. Dr. Behr's description is not enlightening but the specimens from the Henry Edwards material before us probably correctly represent the species. It has the contrasting shades of ground-color, dark within and light without the extradiscal rows of spots beneath, a character noted in *chlorophora*, but is otherwise quite different. The color beneath is warm brown, a different shade entirely from the *sæpium* races, and the markings are differently and more regularly placed. An examination of the male genital armatures of the various forms showed slight differences.

***Incisalia polios* ab. *davisi*, new aberration**

This aberration differs from normal *polios* Cook and Watson in having the hoary gray shading which covers the outer half of the under side of the secondaries confined to the area between the veins in the form of elongate elliptical radiations. The series of chestnut-brown dots occurring in the usual form are here produced as a series of larger lunate spots one occurring in each radiation. The margins of the wings have a series of triangular spots of the dark brown ground-color, which color extends up the veins separating the gray radiations.

Holotype male.—Manchester (now called Lakehurst), New Jersey, April 29, (W. T. Davis); in The American Museum of Natural History from the collection of F. E. Watson and named for our good friend, Mr. William T. Davis.

***Heodes xanthoides luctuosa*, new subspecies**

This differs from the typical form of *xanthoides* (Boisduval) in being generally paler in ground-color on both wing surfaces, the males and females being equally characteristic in this particular. The orange marginal markings of *xanthoides* are replaced in the new form above and below by pale lemon markings and their areas are not so extensive and beneath in the anal area of the secondaries obsolete. Beneath, the ground-

color is strikingly different from the warm buff appearance of *xanthoides*, in the new form being a light whitish gray. Expanse about the normal of *xanthoides*.

Holotype male, allotype and paratype male.—Tehachapi, California, July 2, 1918 (John Comstock); in the collection of Wm. P. Comstock. The paratype is deposited in The American Museum of Natural History.

***Heodes hypophlæas hypophlæas* ab. *fulliolus* (Hulst)**

A single male in fresh condition now in the collection of G. C. Hall was captured on Staten Island, N. Y., May 20, 1919, by O. Fulda. This aberration has not previously appeared in any of our local lists.

The form *fasciata* (Strecker) and aberration *obliterata* Scudder also do not appear in any of our local lists but we have specimens in our collections which were captured within the limits of New York City as well as in its vicinity.

Our reason for changing the status of *fasciata*, from aberration to form, is its frequency of occurrence in certain localities. It was described by Strecker, as an aberration, from a single female taken in Florida but in light of the present known distribution we feel that it should be elevated in rank. This form is of frequent occurrence at Sharon and Woods Hole, Massachusetts, Fox Hills, Staten Island, New York, and in certain localities on Long Island, New York. In a considerable series from these localities many specimens show the tendency to prolongation and irregularity of the spots.

***Heodes hypophlæas hypophlæas* ab. *banksi*, new aberration**

This aberration differs from typical *hypophlæas* (Boisduval) in the markings of the primaries on the upper side. The extradiscal row of six black spots merges with the border of the wings. This is apparently produced by the widening of the wing border but comparative measurement made with typical specimens of *hypophlæas* shows that this is not the case. The merging is caused by an actual shifting of the extradiscal row of black spots, except the subapical ones, toward the slightly broader outer border and by the prolongation of the spots on their outer sides into the border where their bright black is contrasted with the rusty black color of the border. The paratype male is slightly different in appearance from the holotype male in that the extradiscal black spots are smaller and depend almost entirely upon the shifting of their position to cause them to merge with the border. Also, in the paratype the copper color is of a paler tint. The two spots in the discal cell in both specimens are normal in size and position.

On the under side of the primaries, the shifting of the spots toward the border holds equally, but because of the pale gray color of the border, the shifting is not so apparent but is definitely revealed by comparative measurement with normal specimens. Taking the third spot from the hind margin as an instance for comparison, it was found that this spot in both specimens of the aberration now described is nearer the outer margin by a space equal to the width of the spot itself.

The secondaries are normal above and below and the size of the specimens is normal, the expanse is 29 mm. in the type and 28 mm. in the paratype.

A most interesting point in connection with this aberration is the relation to the form *fasciata* (Strecker) in which the extradiscal row of spots is prolonged toward the base of the wing. In *ab. banksi* the spots are prolonged and moved in the opposite direction or toward the margin. Thus this aberration is produced by an action directly opposite to that which takes place in *fasciata*.

Holotype male.—Lexington, Massachusetts, July 17, 1897, (C. Bullard); in the Museum of Comparative Zoology, Cambridge, Massachusetts.

Paratype male.—Lexington, Massachusetts, July 18, 1897, (C. Bullard); from the collection of the Museum of Comparative Zoology, deposited in The American Museum of Natural History.

We take pleasure in naming this interesting aberration for Mr. Nathan Banks.

***Philotes enoptes mojave*, new subspecies**

The male of this race is paler in appearance than *enoptes* (Boisduval); while *enoptes* is of a blue comparable to *comyntas* (Godart), this new form is of the same blue as *pseudargiolus* (Boisduval and LeConte). Its smaller size (expanse 21 mm.) is also noticeable at once, as it is only about three-fourths the expanse of *enoptes*. On the upper side, the dark markings are a dark gray rather than blackish and consist of an edging on the outer margin, barely a millimeter in width, which is continuous on the primaries and interrupted by the veins to form a series of border spots on the secondaries. Fringes are blackish at base and white at extremity and alternately black and white on primary, as in *enoptes*. Beneath, the males are similar in every respect to *enoptes* except in size, the markings being reduced in proportion. The male genitalia have been carefully studied and compared with other species and subspecies of the genus *Philotes* and show that this race is most closely

allied to *enoptes*. The valves are of the same outline as *enoptes* but differ in that the characteristic saw-tooth outer edge is reduced to a single terminal spike followed by two small prongs. This would indicate a relationship to *rita* Barnes and McDunnough, which is, however, offset by the shape of the penis, which has the narrow-lobed base of *enoptes* and not the broad-lobed base of *rita*.

The female is similar in appearance to *enoptes* female on the upper side and beneath it is similar in aspect to its own male, though more heavily marked. The allotype is a poor specimen but the presence of blue scales at the base of the wings above is noticeable to a greater degree than in the females of any of the other species of *Philotes* before us. Expanse 22 mm.

Holotype male and allotype.—Mojave Desert, California, April 18, 1913; both in the collection of Wm. P. Comstock.

Paratype male.—Mojave Desert, California, April 18, 1914; from the collection of Wm. P. Comstock and deposited in The American Museum of Natural History.

These three specimens were obtained through a dealer and no further information than that given above was available.

For working out the identity of the species in the genus *Philotes*, reference should be made to the valuable papers by Barnes and McDunnough in the various numbers of their 'Contributions to the Natural History of the Lepidoptera of North America' and to the paper by R. C. Williams, Jr., in the Entomological News, 1918, XXIX, p. 99.

***Philotes sonorensis* ab. *sonoralba*, new aberration**

The male of this form varies from typical *sonorensis* (Felder) in having the two red spots on the primaries above replaced by two cream-white spots which are larger and more prominent than is usual for the normal red spots to be. Beneath, there is no trace of red whatsoever, the area where it normally occurs being cream-white a shade deeper than that of the spots upon the upper surface. In normal specimens it will be noted that the red spots beneath are surrounded by a cream-white area. In other respects the aberration does not vary from typical specimens.

Holotype male.—San Diego, California, February 26, 1909, (L. E. Ricksecker); in the collection of Wm. P. Comstock.

***Plebeius acmon* ab. *labecula*, new aberration**

The male and female of this aberration differ from typical *acmon* (Doubleday and Hewitson) in that the extradiscal rows of spots on the under side of the wings are obsolete to absent.

Individual characters of the male specimen not cited as diagnostic are its small expanse (18 mm.), the reduced area of the pinkish orange markings of the secondaries above, and the pronounced development of the cell-spot on the secondaries beneath. The female expands 30 mm. and is normally colored and marked in every respect except for the absence of the extradiscal rows of spots beneath.

It is of interest to know that Henry Edwards, in whose collection these specimens were, recognized their peculiarities and labeled them as varieties of *acmon* not, however, giving them a name.

Holotype male.—San Francisco district, California, (Henry Edwards). Allotype.—Nevada, (W. T. Eaves). Both in the collection of The American Museum of Natural History.

Article XI.—SOME NEOTROPICAL MELIPONID BEES

BY T. D. A. COCKERELL

The following report deals with a series of meliponid bees belonging to The American Museum of Natural History. Those from British Guiana and Brazil were collected by H. E. Crampton and Frank E. Lutz of the Department of Invertebrate Zoology expedition to Kaieteur Falls and Mt. Roraima in 1911. Their notes concerning the various collecting places are given at the end of this article.

***Melipona fasciata barticensis* Cockerell**

What was intended to be the original description of this insect was published in 1919, Proc. U. S. National Museum, LV, p. 200, but a later manuscript containing a description was published earlier, 1918, Bull. Amer. Mus. Nat. Hist., XXXVIII, p. 688. The 1918 paper will have to be considered as the original description and the Penal Settlement, Bartica, British Guiana, specimen as the type. The present specimens were collected in the Kaieteur region of British Guiana from the forest (Lutz, Aug. 13) and also from the open savannah (Crampton, July 21).

***Melipona fasciata cramptoni*, new subspecies**

Worker.—Clypeus reddish with a creamy white median stripe and the lateral corners broadly of the same color; inner orbits with a narrow cream-colored band, failing above, and the area mesad of the band more or less reddish; scape with a ferruginous stripe, sometimes distinct only on the lower half; hair of front mixed pale fulvous and dark fuscous, of vertex and occiput mainly ferruginous but partly fuscous, especially at sides; scutellum and axillæ pale yellow; thorax dorsally and upper half of pleura with bright ferruginous hair, becoming dark reddish brown (some of the hairs nearly black but the general effect a warm, rich color) on upper part of mesopleura, anterior corners and posterior middle of mesothorax, and disc of scutellum; lower part of pleura with white hair; wings dusky; legs bright ferruginous; abdomen black, with narrow, entire, pale bands.

The specimens came from an "island" of forest in the wide upper savannahs on the Paiapalu Creek, northern Brazil, August 13 and 15. Their nest was in a hollow of a dead tree. The honey was medium golden in color and somewhat acid. (Crampton.)

This is a distinct race, differing as follows from related forms:

From *M. fasciata panamica* Ckll. by the distinct pale face markings, red hair of vertex, clear red legs, and darker stigma.

From *M. fasciata costaricensis* Ckll. by the bright fulvous hair of head and thorax above, as well as by other characters.

From *M. fasciata barticensis* Ckll. by the brownish tint of part of the thoracic hair, duskier (less yellow) wings, darker stigma, and more distinct face-markings.

As compared with the other forms of *fasciata*, *cramptoni* seems distinctly more robust.

***Melipona interrupta oblitescens* Cockerell**

British Guiana.—Tumatumari; July 11; (Lutz). Tukeit; July 17 and 21. A snake had been killed and skinned the 15th. *Trigona recurva* was very abundant at the carcass on the 16th and, on the 17th, both *Trigona pallida* and *Melipona interrupta oblitescens* were collected there. Apparently they not only sucked the fluids but also carried off small bits of the flesh. Diptera were relatively rare about the carcass (Lutz). Kaieteur; July 19 and 21; (Crampton).

Brazil.—Near the Cotinga River, August 9; (Crampton).

These are the first exact locality records for this form, which was described (1919, Proc. U. S. Nat. Museum, LV, p. 205) from a specimen labelled "Surinam."

***Melipona lateralis* Erichson**

In 1848, in Schomburgk's work on British Guiana, p. 592, Erichson described a new bee as *Melipona lateralis*. I am indebted to Dr. Lutz for a copy of the description, of which the following is a translation.

Allied to *M. favosa*. The head black, front and vertex black-haired; the clypeus anteriorly red-brown in the middle with a yellow longitudinal line; antennæ brown-red beneath, black above; mesothorax and scutellum black-haired; sides of thorax with thick yellow pubescence, but beneath and on metathorax it is gray. Abdomen above hining black, rather bare, the first segment red-yellow, the following four with an apical yellow band; the venter yellow, with short gray hair; legs black, black-haired; wings yellowish hyaline.

This species, which has been ignored since its publication, or at most merely cited from the original reference, is obviously a true *Melipona*. It is to be compared with *M. quadrifasciata* Lep. and *M. intermixta* Ckll. The hair of the thoracic dorsum is described as black, without qualification, and this points to *M. quadrifasciata*. If, however, we allow for a certain amount of inexactness, the description applies well to *M. intermixta*, which is more likely to have been collected in the region from which *lateralis* came. The description of the clypeus is excellent for *intermixta*, but there is no mention of light stripes along the orbits. On the whole, I believe that *M. lateralis* is the valid and prior name for *intermixta*, but it probably applies to a race differing in some respects from those at present known. In that case the nomenclature will be:

Melipona lateralis lateralis Erichson.

Melipona lateralis intermixta (Ckll.)

Melipona lateralis kangarumensis, new subspecies.

***Melipona lateralis kangarumensis*, new subspecies**

Worker.—Like *intermixta* but the ground-color of the abdomen is clear ferruginous. It is larger than *M. quadrifasciata callura* Ckll., and the abdomen is clear red at the base.

British Guiana.—Kangaruma, the type locality, July 13; also August 18 in the forest near this place; (Lutz). Four specimens.

Brazil.—Savannah a little west of Brazilian border and Ireng River (barometric reading, 3450 feet) and also in a small patch of forest in the upland savannahs (barometric reading, 4000 feet) near Mt. Weitipu; August 7 and 15; (Crampton). The two specimens from the lower savannah have the abdominal bands inconspicuous and look different. They are, perhaps, not quite mature, and one has the bands reddened by cyanide.

***Melipona pseudocentris* Cockerell**

Kangaruma, British Guiana; July 13; (Lutz). This species was previously known only from Brazil (Cockerell, 1912, Psyche, XIX, p. 47, and, 1919, Proc. U. S. Nat. Museum, LV, p. 202).

***Trigona fulviventris* Guérin**

Guatemala; December 1908; (Engelhardt). The specimens are from the Zabriskie Collection, which is deposited in the American Museum. The species ranges from Mexico to Brazil. Its absence from the British Guiana collection is surprising, as it is so very abundant in many other neotropical regions. The U. S. National Museum has it from Cacao, Trece Aguas, Guatemala, (G. P. Goll); S. Antonio, Nicaragua; Sonsonate, Salvador, (F. Knab); Esparta, Costa Rica, (F. Knab); Pozo Azul, Costa Rica, (Carriker); Cordoba, Mexico, (F. Knab); and the following localities in the Panama region: Las Cruces (Busck), Porto Bello (Busck), Alafaela (Jennings), Gatun (Jennings), Paraiso (Busck), Alhajuelo (Busck), and Cabima (Busck).

***Trigona jaty* Smith**

Ollas de Moka, Guatemala; December 5, 1908; (Engelhardt); also from the Zabriskie Collection. This species was described from Brazil (I have seen it from Pará) and has been previously reported from Guatemala but not elsewhere. Specimens in the U. S. National Museum come from San José, Guatemala (F. Knab); Tabernilla, Canal Zone,

Panama (Busck); Pozo Azul, Costa Rica (Carriker); and Nicaragua. Some of the Nicaragua specimens have the abdomen dark. *T. varia* Lepeletier resembles *T. jaty*, but is larger (anterior wing 7 mm. long), and the face is broader. It occurs in Brazil.

***Trigona bipunctata wheeleri* Cockerell**

Guatemala; December 3 and 5, 1908; (Engelhardt); from the Zabriskie Collection. This form has been confused with *T. mexicana* Guérin; but the latter, as I understand it, is distinct (cf. Trans. Amer. Ent. Soc., XXXI, p. 323). The specimens from Guatemala in the U. S. National Museum, determined by Friese as *mexicana*, do not agree with *mexicana* as named in the British Museum. As far as known, *wheeleri* has not been found outside of Guatemala.

***Trigona frontalis* Friese**

Environs of Guadalajara, State of Jalisco, Mexico; (Digue). Previous records are from Honduras, Nicaragua, Guatemala, and Ecuador. A variety, *flavocincta* Cockerell, occurs in Guatemala and Brazil, and was taken by A. Busck at Paraiso, Canal Zone, Panama, January 28.

***Trigona clavipes* (Fabricius)**

British Guiana.—Rockstone; July 9; (Lutz). Tumatumari; July 11; (Crampton and Lutz). Potaro Landing; August 18; (Lutz). Saveritik near the Ireng River; open spaces in an Indian village; August 5; (Crampton). This species has been previously reported from Brazil and Uruguay.

***Trigona williana* Friese**

British Guiana.—Rockstone; July 9; (Crampton). Kaieteur; forest; August 12; they chew up human excrement and deftly pat it into balls on their hind legs; (Lutz). Saveritik; August 5; (Crampton).

Brazil.—Open savannah west of Cottinga River; August 17; (Crampton).

I now find that I was in error in separating *T. rhodoptera* (1912, Psyche, XIX, p. 49) from *T. williana* Friese (1900, Termés Füzetek, XXIII, p. 388). I have since seen authentic *williana* in the U. S. Nat. Museum and have compared it with my type of *T. rhodoptera*, which I have placed in the Museum. *T. williana* is known from Dutch Guiana and Brazil; *rhodoptera* has been previously reported only from the original material collected by Mann and Baker on the Rio Madeira, Brazil.

The following table, based on specimens in the U. S. Nat. Museum, separates a series of species in which the mesothorax is all red.

1. Hind tibiae with more than the apical half fuscous, the base pallid; abdomen mainly reddish fuscous; specimen from Pará, Brazil. . . . *rhumbleri* Friese.
Hind tibiae clear red. 2.
2. Wings milky whitish; abdomen narrow; specimens from Bolivia and Pará, Brazil.
dallatorreana Friese.
Wings reddish or dusky. 3.
3. Smaller, anterior wing about 6 mm.; thorax wholly red; specimen from Brazil.
pallida (Latreille) = *kohli* Friese.
Larger, anterior wing about 8.5 mm.; specimen from Brazil. . . . *williana* Friese.

Specimens in the U. S. Nat. Museum from Tarata, Bolivia, also marked *kohli* by Friese, belong to quite another species.

***Trigona heideri* Friese**

British Guiana.—Potaro Landing; August 18; (Lutz). Amatuck; August 17; (Lutz). Chenapowu Creek; at flowering bushes along the stream; July 31; (Crampton). This species belongs in the subgenus *Tetragona* and was described by me as *T. manni* from material collected by Mann and Baker on the Rio Madeira, Brazil (Cockerell, 1912, Psyche, XIX, p. 48). I have found by comparison with specimens determined by Friese that *T. manni* is identical with *T. heideri* Friese (1900, Termés Füzetek, XXIII, p. 389), which was described from Brazil, Peru, and Colombia, its varieties or subspecies extending its distribution to (*mocsaryi* Friese) Dutch Guiana and (*occidentalis* Schultz) Ecuador. The variety or species *mocsaryi*, of which I have seen authentic material from Pará (U. S. N. M.), is easily distinguished by the red hind tibiae, lacking dark markings. It has the anterior wing about 8 mm. long, orange tinted, with the apical margin broadly pale gray. The *occidentalis* form has the dorsum ferruginous or yellowish; I have not seen it.

***Trigona pallida* (Latreille)**

British Guiana.—Rockstone; July 9; (Lutz). Tumatumari; July 11; (Lutz). Tukeit; July 16-19; at a snake carcass (see *Melipona interrupta oblitescens*) and called "colatakwa" by our Patamona Ackawoi Indians (Lutz); also flying to jam in the camp tent (Crampton). Kaieteur; July 19 to August 5; at the carcass of a monkey; (Lutz).

These specimens agree with a specimen from F. Smith's collection, determined by him as *pallida*. The insect in the U. S. National Museum from Peru and determined by Ashmead as *pallida* is quite different, falling with or very near to *goettei* Friese. *T. kohli* Friese is identical

with *T. pallida* as understood by Smith and here recognized. *T. pallida* was originally known from French Guiana and has since been reported from Brazil; *kohli* was described from French and Dutch Guiana, Brazil, Peru, and Colombia; these are the first records from British Guiana. Specimens in the U. S. National Museum collected by Busck in the Panama region (Tabernilla, La Chorrera, Rio Trinidad and Alhajuelo) are a little darker, with darker wings, than Brazilian *kohli*, but hardly seem to constitute a distinct race.

***Trigona musarum* Cockerell (? *rhumbleri* Friese)**

From the forest east of the Cotinga River, Brazil; barometric reading, 4000 feet; August 10; (Crampton).

The three workers in this collection differ from typical *musarum* by having the hind tibiae dark fuscous except basally, and the hind basitarsi also dark, while the middle basitarsi are inclined to be darkened. This brings it close to *T. rhumbleri* Friese; but Friese's two-line description is hard to interpret, as he compares the species with *pallida* and we do not know what his "*pallida*" was. I saw authentic *rhumbleri* in the U. S. National Museum, but did not make comparisons with *musarum*. Should they prove forms of one species, *musarum* will stand as a subspecies. *T. rhumbleri* is known from Brazil, Peru, and Colombia; *musarum* from Costa Rica and Panama.

***Trigona cupira* Smith**

There are specimens collected by C. F. Davis in Panama and by C. Werckele at Pacayas, Costa Rica. The species has been previously reported from Costa Rica, Guatemala, and Brazil. In the Panama region it has also been taken at Cabima (Busck) and Porto Bello trail (A. H. Jennings).

***Trigona recursa* Smith**

British Guiana.—Tumatumari; taken by sweeping in a grass field, July 11; (Lutz). Potaro Landing; August 18; (Lutz). Kangaruma; July 13; (Lutz). Tukeit; at the carcass of a snake (see *T. pallida*); July 16; (Lutz). Kaieteur; both in the forest and on that part of the open savannah where there was either bare rock or very few grasses and small, low flowers; July 30 to August 5; some of those from the forest were at the carcass of a dead monkey and others at fleshy flowers which had fallen to the ground from the high trees along the river; (Lutz). Saveritik; at flowers in an open clearing on the border of the Ireng River; August 5; (Crampton).

Most of the very numerous specimens came from the Tukeit dead snake that seemed to be popular with both genera of Meliponidæ. I have one of F. Smith's specimens of *recurva* for comparison. The long hair on the mesothorax and scutellum distinguish it from what I have identified as *T. stigma* Smith. The species is given as "*recurva*" in Dalla Torre's catalogue and was previously known only from Brazil.

***Trigona amalthæa* (Olivier)**

British Guiana.—Rockstone; July 9; (Lutz). Potaro Landing; August 18; (Lutz). Kangaruma; July 13; (Lutz).

This species ranges from Mexico to Ecuador and Brazil. Gaige had taken it at Dunoon, British Guiana (see Cockerell, 1916, Occ. Papers. Mus. Zool., University of Michigan, No. 24). *T. fuscipennis* Friese is a synonym.

In the U. S. National Museum is a piece of bark of the "Mulungú tree," obtained by Branner and Koebele in 1883 at "Bnito, Prov. Pernambuco," Brazil. On it are some homopterous insects (*Æthalion reticulatum* Fb., variety, det. Heidemann), exactly the color of the bark. These are attended by *Trigona amalthæa* and two species of beetles (det. Barber) of the genus *Conotelus* and *Cryptorhopalum*.

***Trigona ruficrus corvina* Cockerell**

Tumatumari, British Guiana; July 11; (Lutz). The typical form is known from Guatemala, Brazil, and Paraguay; *corvina* was previously recorded from Guatemala, Costa Rica, and Panama.

***Trigona townsendi* Cockerell**

This is not in the collection sent, but I take the opportunity to record a series of new localities for specimens in the U. S. National Museum. Alhajuelo. Canal Zone, Panama; March 12; (Busck). Escuintla, Guatemala; (F. Knab). Cacao, Trece Aguas, Guatemala; (Schwarz and Barber). Boruca, Costa Rica; July; (M. A. Carriker).

***Trigona subgrisea*, new species**

Worker.—Length about 5.5 mm., anterior wing 5.5 mm.; black, the abdomen and legs faintly reddish; mandibles edentate, reddened apically; head large and broad, shining; face with thin pale hair, not conspicuous; front and vertex with ochreous-tinted hair; extreme base of antennæ fulvous, but scape otherwise black; flagellum black, obscurely brown beneath; thorax with pale ochreous-tinted hair, fulvous on scutellum; mesothorax and scutellum polished and shining; tegulæ testaceous, with a large dark spot; wings hyaline with grayish dusky tips, nervures on basal half bright clear orange-ferruginous; legs with reddish hair, but white tomentum on inner side of basal half of hind tibiæ; hind tibiæ only moderately broad, the fringing hairs pale

reddish; abdomen shining, rather narrow, the margins of fourth and fifth segments, and sixth segment, with more or less evident pale brownish hair, the ventral surface with white hair.

East of the Cotinga River, Brazil; August 10; (Crampton). Two workers, one in bad condition.

In my manuscript table this runs nearest to *T. leucogastra* Ckll., from Ecuador, but it is easily separated by the color of the hair on thorax.

***Trigona pura*, new species**

Worker.—Length about 6 mm., anterior wing about 6 mm.; black, with yellow face-markings, scutellum pale honey-color, first abdominal segment pale reddish, second brownish black, pallid at anterior lateral corners; legs dark reddish, the anterior femora pallid basally, the others more extensively, the tarsi pale reddish apically. Head ordinary, face and front brilliantly shining; mandibles edentate (except for the inner notch), the apical half ferruginous; face and front with thin pale hair, vertex with fulvous; face-markings consisting of a broad median band on clypeus (narrowed above and crenulate at sides), a little marginal spot on each side of clypeus, broadly triangular supraclypeal mark, and rather narrow bands (broadest below) along inner orbits to the summits; scape long, yellow in front, behind pale red with a dark spot at apex; flagellum dark reddish above, paler beneath, with a lighter spot on each segment; mesothorax and scutellum shining; thorax above with abundant fulvous hair; upper border of prothorax with a yellow (tegumentary) band; hind tibiae not very broad; tegulae pale testaceous; wings clear hyaline, distinctly milky, stigma and nervures pale orange-ferruginous; abdomen long and narrow, highly polished, apex above with fuscous hairs.

Kaieteur, British Guiana; July 21; (Crampton). One worker. Looks much like *T. clavipes* (Fabr.), but easily known by the face-markings and other characters.

***Trigona droryana* Friese**

In the U. S. National Museum are specimens from Rio Janeiro, Brazil, labelled *T. droryana* Friese and *T. mosquito* Smith by Friese. The *droryana* have the tegulae testaceous, and scape pale in front to apex; the *mosquito* have the tegulae rufofuscous, and the scape in front black apically. After close study, I concluded that these were merely forms of a single species, very easily recognizable by the small size, mesothorax shining, axillae pale, scutellum pale-margined, anterior and middle tibiae red, hind margins of abdominal segments black.

The insect recognized as *T. mosquito* by Friese is widespread, having been taken at Acapulco, Mexico (F. Knab) and Cacao, Trece Aguas, Guatemala (Goll). Smith described his *T. mosquito* as having the abdomen entirely pale, scutellum pale, etc. It surely cannot be identical with the species so determined by Friese. Whether *T. emerina* Friese

is the true *T. mosquito*, as Marianno indicates, I cannot say. It has the pale scutellum, but the abdominal segments are dusky-margined. Specimens of *T. emerina* from Brazil, determined by Friese, are in the U. S. National Museum. They are totally distinct from *droryana*, and belong to the group of very small species, in which *emerina* is known by the shining mesothorax (dull in *T. schrottkyi* Fr.) and clypeus dark (pale in *T. goeldiana* Fr. and *duckei* Fr.).

For the present, at least, the species above recorded from Mexico and Guatemala must stand as *droryana*.

Stations in British Guiana and Brazil

ROCKSTONE, British Guiana. On the Esequibo River. Barometric reading, about 50 feet. The meliponids came from an open, sandy flat. The vegetation was sparse and xerophytic.

TUMATUMARI, British Guiana. On the Potaro River. The specimens reported on here came from a relatively dry and level area along the river. The chief vegetation was grass, weeds, and low bushes. The surrounding vegetation was forest.

POTARO LANDING, British Guiana. On the Potaro River above Tumatumari. The collecting area was sandy country with sparse vegetation (somewhat less xerophytic, however, than at Rockstone) along the river and for about two miles inland. It was bordered by forest.

KANGARUMA, British Guiana. On the Potaro River about six miles above Potaro Landing. A clearing made some time ago and now rather grown up.

AMATUK, British Guiana. On the Potaro River above Kangaruma. Barometric reading, 250 feet. A small recent clearing in the forest at the river's edge.

TUKEIT, British Guiana. In the gorge of the Potaro River five miles below Kaieteur Falls. Barometric reading, about 275 feet. A small clearing in the forest at the river's edge and along paths and in open places among the tall forest trees.

KAIETEUR, British Guiana. On the Potaro River above the falls on the plateau. Barometric reading, about 1325 feet. There are two types of country here: (1) the open savannah with low vegetation, scattered trees and the giant, terrestrial bromeliads; and (2) the rain-forest. The things recorded from the forest came from the relatively dry portions, especially from open glades near the river.

CHENAPOWU CREEK, British Guiana, a small affluent of the Potaro River, about 30 miles west of Kaieteur. The specimens were taken on bushes bordering the streams, where there were no high forest trees.

SAVERITIK, an Indian settlement on the Guiana side of the Ireng River, which separates British Guiana and Brazil. The specimens of *T. recursa* and *T. clavipes* were taken on flowering plants and near the village clearing, while *T. williana* was taken in the neighboring forest.

COTINGA RIVER, Brazil. *M. oblitescens* from forest on the eastern divide of the Cotinga Valley. Barometric reading, 4400 feet. *T. musarum* was taken in forest on the higher eastern borders of the Cotinga River valley. Barometric reading 4000 feet. *T. subgrisea* and *M. oblitescens* were secured in forest areas of a town level. Barometric reading, 2500 feet. *T. williana* was taken on the open savannah a little west of the Cotinga River. Barometric reading, 2500 feet.

KANAIRENG RIVER, Brazil, a small river running southward about 12 miles west of the Ireng River and the Brazilian border. The specimens were taken on the open savannah. Barometric reading, 3450 feet.

MT. WEITIPU, Brazil. Small patch of forest in the upland savannahs at the base of Mt. Weitipu. Barometric reading, 4000 feet.

PARAPALU CREEK, a small branch of the Arabopo River, Brazil. The specimens were taken in an "island" of forest, surrounded by open savannahs. Barometric reading, 4000 feet. The bees were taken from the nest in the hollow of a dead tree, as well as from the natives' hair and on the wing. The honey was acrid, and golden brown in color. The "cells" were made of chocolate-brown wax, and were globes about one or one and a half inches in diameter.

Article XII.—NEW MAMMALS FROM JAMAICA

BY H. E. ANTHONY

Plate XXXIII

As a continuation of the policy of The American Museum of Natural History to carry on investigations of the West Indian fauna, an expedition to Jamaica, British West Indies, was undertaken jointly by the departments of Vertebrate Palæontology and Mammalogy late in 1919. The author was in charge of the work and had, as an assistant, Mr. Charles Falkenbach of the department of Vertebrate Palæontology. The expedition was in the field from November 18, 1919, to March 19, 1920, and secured large collections of mammals, both of living and fossil forms. The preparation for study of the fossil material, which is almost all in a hard breccia, will necessarily take many months and this preliminary report is for the purpose of recording such results as are obvious from the available material. It is planned to publish a detailed report of the collections at the earliest possible moment.

The most striking finds of the expedition are large hystricomorph rodents of which at least four distinct new genera were found, very probably belonging to two separate families. Two well differentiated species of one of these genera are represented in the material, while the other genera appear to be monotypic. Seemingly the most common member of the fossil fauna is the following genus.

***Clidomys*,¹ new genus**

A large hystricomorph characterized by a molar pattern made up of subelliptical laminae, separated by cement, each lamina with the enamel completely encircling it. The number of these laminae is normally three, the number of the cheek-teeth is the normal hystricomorph number, four, and the teeth are rootless.

Genotype: *Clidomys osborni*.

***Clidomys osborni*,² new species**

Plate XXXIII, Figures 1 to 5; Text Figures 1, 2, and 3

Type: No. 17634, Department of Vertebrate Palæontology, from a cave on the Wallingford estate, Balaclava, Jamaica, December 1919; collector, H. E. Anthony. The type is a fragmentary mandibular ramus, left, with all of the molar series but lacking the incisor and all of the ascending portion of the ramus.

¹From *κλεις* (*kleis*), a key and *μῦς*, a mouse.

²For Professor Henry Fairfield Osborn, President of The American Museum of Natural History, whose support and interest in the West Indian work has stimulated museum activity there.

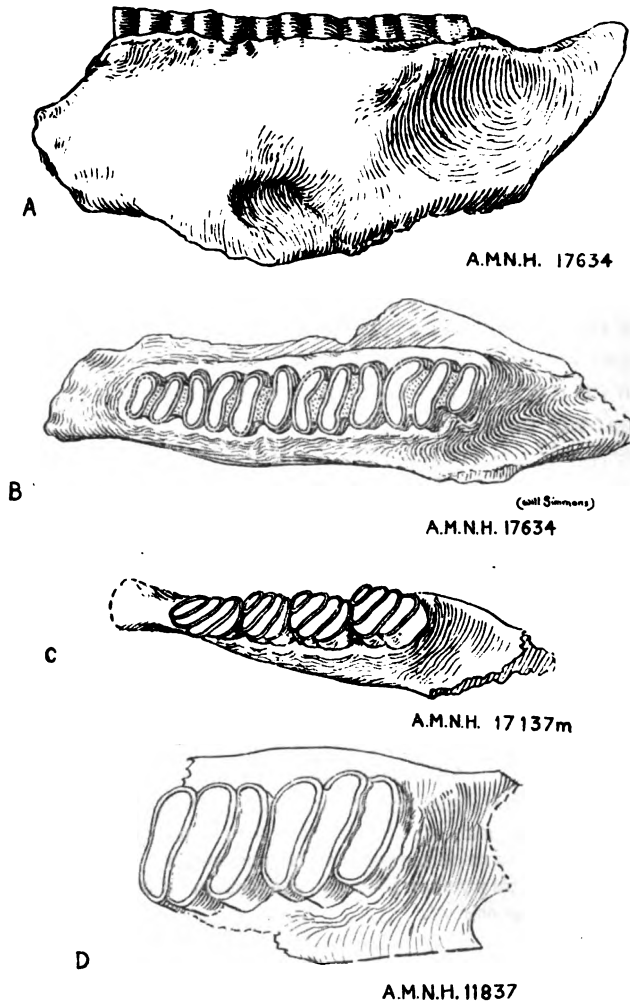


Fig. 1

- A. External view of left mandible of *Clidomys osborni*.
 B. Crown view of mandibular molar series of *Clidomys osborni*.
 C. Crown view of mandibular molar series of *Elasmodontomys obliquus*.
 D. Crown view of last two mandibular molars of *Amblyrhiza inundata*.
 All figures natural size.

DESCRIPTION.—Mandible robust and strong, with great transverse thickness; muscle insertion areas apparently well developed; toothrow of good length, the molars subequal in size and slightly larger than the premolar; each tooth made up of three laminae cemented together, each lamina completely encircled by enamel to form a simple subelliptical pattern in the crown; the anterior ellipsoid of m_1 , m_2 , and m_3 with the posterior loop of enamel concave instead of convex; the laminae set in the toothrow with a slight obliquity to the long axis of the row; amount of cement in the crown pattern about 30 per cent of the dentine; teeth rootless but projecting only moderately above alveoli and not decidedly hypsodont.

MEASUREMENTS.—Crown length of toothrow, 46.2 mm.; dimensions of pm., 9.8×7 ; m_1 , 11.1×9.5 ; m_2 , 11.4×9.1 ; m_3 , 12.2×8.8 ; dimensions of laminae of m_3 , in antero-posterior order,¹ 8.9×2.4 ; 9.1×2.6 ; 8.5×2.7 .

Clidomys is unique among West Indian hystricomorphs (1) in the complete and unreduced encircling enamel of each lamina and (2) in the extensive amount of cement between the laminae. It doubtless represents the more primitive stage through which has passed *Elasmodontomys* and *Amblyrhiza*, since in these forms the enamel has almost disappeared along the anterior face of each lamina (lower molars) and the cement has

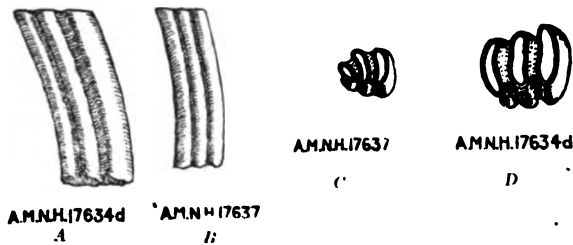


Fig. 2.

A, D. Lower molar of *Clidomys osborni*.

B, C. Lower molar of *Clidomys parvus*.

All figures natural size.

been reduced to a very thin sheet. In this respect it more nearly resembles *Megamys* and *Tetrastylus*, which the figures of Ameghino show to have a greater number of laminae than has *Clidomys*. With the rodents of the Santa Cruz beds the Jamaican genus has little in common. *Clidomys* is also more primitive than *Elasmodontomys* in the proportionally shorter length of the molars and the more normal, less oblique, relation of the laminae to the axis of the toothrow. *Clidomys* differs strikingly from all living hystricomorphs, the closest similarity among the mainland forms being seen in the genera *Lagostomus* and *Chinchilla*, but these rodents show little of the extreme differentiation of the molars into heavy enamel and wide areas of cement.

¹The second measurement is the average breadth or thickness of the lamina.

With considerable skeletal material of *Clidomys* on hand, needing only time in the laboratory to make it available, it would be premature to indulge in conjecture, in this paper, as to the relationships of this new genus. It is significant, however, that the dentition shows *Clidomys* to be only remotely related to the other large hystricomorphs of the West Indies, and thus casts much doubt upon the tertiary connection of Jamaica with any other of the Greater Antilles. It is hoped that a better understanding of the relationships of *Clidomys* will yield important evidence as to the geological history of Jamaica and this idea has been incorporated in the name of the genus.

Among a number of molar teeth which have no definite known associations, other than being found in the same cave, are several which are decidedly smaller than the rest and evidently represent a different species.

***Clidomys parvus*, new species**

Plate XXXIII, Figures 6 and 7; Text Figure 2

Type: No. 17637, Department of Vertebrate Palæontology, from a cave on the Wallingford estate, Balaclava, Jamaica, December 1919; collector H. E. Anthony. The type is a single tooth, presumably the premolar from the left mandibular ramus.

DESCRIPTION.—Proportionally rather long and slender, slightly curved, with essential elements of the crown pattern typical of the genus, but with a marked difference in the sizes of the laminae, the anterior lamina being not more than half as extensive as either the second or third.

MEASUREMENTS (figures in parenthesis are of *osborni*).—Greatest length of tooth, 19.8 mm. (23)¹; dimensions of crown, 6.1×4.4 (9.8×7)².

The figures will show, better than the measurements, the very apparent differences in proportion between *osborni* and *parvus*. The tooth of *parvus*, although nearly as long as that of *osborni*, has a cross-section equal to only 40 per cent of the latter. Such a difference can not be attributed to age, although this group of rodents, to judge by the material at hand, seems to manifest the same dental traits as are found in *Capromys*, *Proechimys* and numerous other rodents, namely the very early appearance of the full molar series and a progressive increase in the cross-section of the molars with age.

There are several other teeth, doubtless of this species, but rather fragmentary in nature. They confirm the characters shown by the premolar and there is a large gap between any of these and the smallest of those of *osborni*.

¹This measurement is of No. 17634d, which is obviously not a premolar, but as the entire molar series appear to be approximately the same length, the measurement will serve to show the proportional difference.

²Measurements taken from the premolar of the type of *osborni*.

Numerous isolated teeth were found in the Wallingford formation and it is hoped that jaws with teeth in position may yet be discovered in the breccia. However, characters of definite diagnostic value appear in these single teeth and it is upon this material that the following three genera are based.

***Spirodontomys*¹ *jamaicensis*, new genus and species**

Plate XXXIII, Figures 8 to 10; Text Figure, 3

Type: No. 17635, Department of Vertebrate Palaeontology, from a cave on the Wallingford estate, Balaclava, Jamaica, December 1919; collector, H. E. Anthony. The type is a single tooth, one of the upper molar series—which one of the series is not very clear, but the choice probably lies between pm^4 and m^3 .

DESCRIPTION.—Laminae completely encircled by enamel; first two laminae ellipsoid and resembling those of *Clidomys*; posterior half of crown pattern made by a horseshoe-shaped fold, completely outlined in enamel, so that the tooth has two deep longitudinal channels on one side and three on the other.

MEASUREMENTS.—Greatest length of tooth, 17 mm.; dimensions of crown, 10.4 × 6.2.

Two other teeth are referred to this form and are worthy of comment. One of them, No. 17635c, is apparently an upper tooth and with the posterior fold only partly closed so that the arm of the horseshoe points in the long axis of the crown instead of across it. No. 17635a is a lower tooth and here the horseshoe has assumed almost a spiral shape.

The material on hand quite definitely shows that *Clidomys* does not have teeth in either jaw with a crown pattern in which the elements deviate from the simple ellipsoid type and consequently a distinction of this sort appears to call for a generic separation although the relationship to *Clidomys* is an apparent one.

***Speoxenus*² *cundalli*,³ new genus and species**

Plate XXXIII, Figure 12; Text Figure 3

Type: No. 17636, Department of Vertebrate Palaeontology, from a cave on the Wallingford estate, Balaclava, Jamaica, December 1919; collector, H. E. Anthony. The type is an upper molar, possibly m^3 , from the right side.

DESCRIPTION.—Proportionally rather longer and more slender than the corresponding tooth of *Clidomys osborni*, with the two anterior laminae typical ellipsoid and the posterior part of the crown pattern composed of two enamel enclosed lakes; two external and three internal longitudinal channels present.

MEASUREMENTS.—Greatest length of tooth, 23.7 mm.; dimensions of crown, 9.6 × 6.3.

¹From *σπείρα*, a coil; *ὀδόν* *ὀδους*, a tooth; and *μῦς*, a mouse.

²From *σπίος*, a cave; *ἐπίος*, a guest.

³For Mr. Frank Cundall, Librarian of the Institute of Jamaica, who gave assistance of great value to the expedition.

Speoxenus appears to be a genus in which the development of the posterior part of the molar is at a stage quite different from that either of *Clidomys* or *Spirodontomys*. Another upper tooth, suspected of belonging to this genus, has three ellipsoid laminae noticeably different from those of *Clidomys* in their degree of obliquity to the toothrow. Both of these teeth are more decidedly hypsodont than the teeth of either *Clidomys osborni* or *Spirodontomys* and resemble *Clidomys parvus* in this respect.

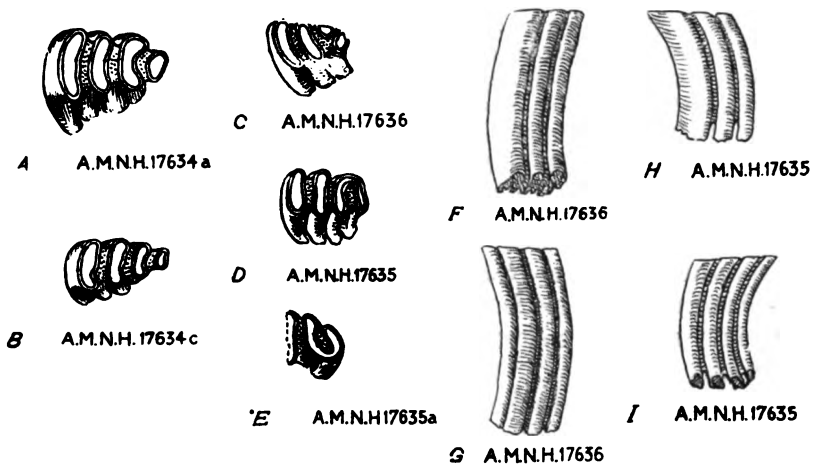


Fig. 3

A, B. Upper molars of *Clidomys osborni* (m?).

C, F, G. Upper molar of *Speoxenus cundalli*.

D, H, I. Upper molar of *Spirodontomys jamaicensis*.

E. Lower molar of *Spirodontomys jamaicensis*.

All figures natural size.

If, at this stage in the work upon the Jamaican material, one may be allowed to venture a guess as to the interrelationships of this group of forms—*Clidomys* with two species, *Spirodontomys*, and *Speoxenus*—the tendency would be to consider them all as derivatives of a single species which had been subjected to the influences of a long insular isolation.

***Alterodon*¹ major, new genus and species**

Plate XXXIII, Figure 11; Text Figure 4

Type: No. 17638, Department of Vertebrate Palaeontology, from a cave in the Wallingford estate, Balaclava, Jamaica, December 1919; collector, H. E. Anthony. The type is a single tooth of the molar series but its position can not be placed with certainty.

¹From ἀλγες, dumb-bells; and δῶν (δδους), a tooth.

DESCRIPTION.—A short, rootless molar, with a simple crown pattern made up of two subequal parts, separated by a narrow waist, resembling somewhat the figure 8 or the longitudinal cross-section of a dumb-bell. The enamel is continuous about the periphery of the crown and does not cross through it at any point.

MEASUREMENTS.—Greatest length of tooth, 14.7 mm.; dimensions of crown, 6.3×5 .

This genus is very obviously quite remote in relationships from any other of the Jamaican complex and, no doubt, is a member of a different family. It bears rather a significant resemblance to the teeth of *Plata-*

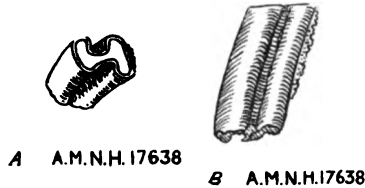


Fig. 4

Molar of *Alterodon major*

A. Crown view; B. Lateral view.

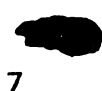
Figures natural size.

omys, figured by Rovereto in the *Anales Museo Nacional Hist. Nat. Buenos Aires*, XXV, page 63, and an even more striking similarity to the recent genera *Octodon* (lower molars) and *Abrocoma* (upper molars). There can be no mistaking the distinctness of this form from any known genus and, for this reason, it has been described on the basis of what might at first glance seem rather inadequate material.

PLATE XXXIII

All figures natural size

- Fig. 1. External view of type mandible, left, of *Clidomys osborni*.
- Fig. 2. Crown view, same mandible.
- Figs. 3, 4. Upper molars (last ?) of *Clidomys osborni*.
- Fig. 5. Lower molar of *Clidomys osborni*.
- Fig. 6. Upper molar of *Clidomys parvus*.
- Fig. 7. Lower molar (type) of *Clidomys parvus*.
- Fig. 8. Lower molar of *Spirodontomys jamaicensis*.
- Figs. 9, 10. Upper molars (No. 10, type) of *Spirodontomys jamaicensis*.
- Fig. 11. Molar (type) of *Alterodon major*.
- Fig. 12. Upper molar (type) of *Speoxenus cundalli*.



Article XIII.—A KEY TO THE SPECIES OF *TRACHURUS*

BY JOHN TREADWELL NICHOLS

Trachurus is one of the most sharply marked genera of *Caranx*-like fishes. The species which comprise it, on the other hand, are closely related and difficult to differentiate.

Cuvier and Valenciennes (1833)¹ recognize but a single, wide-ranging species, more or less variable geographically. Lütken (1880)² differentiates four species: (1) a North-European, (2) South-European, (3) one occurring at the islands of the eastern Atlantic and also on the western coast of South America, and (4) one in Chinese and Australian waters. Jordan and Evermann (1896)³ synonymize the Californian form with Lütken's third. Later American writers, in using the name *Trachurus symmetricus* Ayres, with type locality San Francisco, for the Californian fish, as also for the one from the western coast of South America, imply that these are identical and differ from the one with which Lütken placed them. In an Australian Fisheries report (1915),⁴ two species from those waters are figured as *declivis* and *novæ-zelandiæ*, differing from the Japanese *japonicus*. The above gives seven current species. There is also reference of *Trachurus* from the Cape of Good Hope, said to resemble the North-European fish, curve of lateral line less abrupt, scutes 65 to 75. Whereas recent authors do not recognize this form as distinct, it should be so, geographically, and has been described as *capensis*.

Six species of *Trachurus* are represented in the collections of The American Museum of Natural History. We have two from Naples. One of these is Lütken's South-European species, which he refers to *mediterraneus* Steind. The other resembles his North-European species, but is more slender. Californian material is referable to *symmetricus*, and Japanese to *japonicus*. Material from Peru has been recently received; as also grown material from the Atlantic United States, which is rare.

In differentiating the species of this genus, Lütken does not make use of depth of body as a criterion, perhaps because he found it subject to such great age-variation in other carangin genera. It seems here, however, to be a reliable character and one of the most convenient, and,

¹Cuvier and Valenciennes, 1833, Hist. Nat. Poiss., IX, pp. 11-28.

²Lütken, C., 1880. Spolia Atlantica, Danak. Vid. Selak. Sk., (5) XII, pp. 533-534.

³Jordan and Evermann, 1896, Bull. U. S. Nat. Mus., No. 47, part 1, p. 910.

⁴McCulloch, A. R., 1915, Report on some Fishes., etc., Australia, Fisheries, III, Pl. xxxiv.

although Lütken's characters may give a more reliable idea of the interrelation of the species, depth is used in this paper, as by Jordan and Evermann, in separating them.

Lütken records his North-European fish, which he calls *linnaei*, from the Mediterranean also, enabling Jordan and Evermann to retain *Trachurus trachurus*, with type locality the Mediterranean, for that species. In all probability it was the similar, slenderer form which Linnæus had from the Mediterranean. This should, then, stand as *trachurus*, and the northern one become *semispinosus*. One of the current species is thus divided. Furthermore, on examination of three American fish from Orient, Long Island, recently submitted by Mr. Roy Latham (92, 95 and 125 mm. to base of caudal; taken August 28, September 19 and November 1, 1919), it is found that their accessory lateral line stops under the front of soft dorsal instead of continuing farther back, as emphasized by Lütken for the North-European form, with which they otherwise agree. *Trachurus lathamii* is, therefore, proposed for this American form.

Lacking material from the western coast of South America, the figure of a fish from there (Evermann and Radcliffe, 1917, U.S. Nat. Mus., Bull. No. 95, Pl. v) was studied. This was at once seen to differ from Californian *symmetricus*, in which the anterior scutes are very narrow. Furthermore, it was difficult to find characters to differentiate it from Lütken's description of his third species, which he calls *cuvieri* and which, following Jordan and Evermann, is here synonymized with *picturatus*. This leaves *picturatus* with an anomalous range. Examination of two specimens of *picturatus* from Fayal, kindly loaned by the Museum of Comparative Zoology, Cambridge, led to the conclusion that the Peruvian fish was less slender, with perhaps other slight differences, a conclusion since confirmed by two specimens brought from Peru by Mr. Murphy, one of which is made the type of *murphyi*, here proposed.

We are, again, without material of the two species figured from Australia (1915); the deeper of these identified with *declivis*, the more slender called *novæ-zelandiæ*, reviving an old name credited to Hutton. Comparison with the excellent type figure of *declivis*, however, shows that it is *novæ-zelandiæ*, which should have been referred to it. The deeper is the one left without a name, and for which the name *Trachurus mccullochi* is here proposed. It is close to, possibly identical with, *japonicus*.

The following list epitomizes the writer's views on the synonymy of the eleven species¹ of *Trachurus*, now recognized.

¹The material at hand is insufficient to determine whether they should all stand as full species or some or all be reduced to subspecies.

Trachurus semispinosus (Nilsson)

Caranx semispinosus NILSSON, 1832, Prodr. Ichthyol. Scand., p. 84. Scandinavia.

Range.—Abundant on the coasts of northern Europe.

Trachurus trachurus (Linnaeus)

Scomber trachurus LINNÆUS, 1758, Syst. Nat., 10th Ed., p. 298. Mediterranean.

Range.—Mediterranean.

Trachurus lathamii, new species

Trachurus trachurus JORDAN and EVERMANN, 1896, Bull. U. S. Nat. Mus., No. 47, part 1, p. 910; 1900, *loc. cit.*, part 4, fig. 384. Rhode Island.

Accessory lateral line ending under front of soft dorsal. Depth to base of caudal 3.65; arc of curve of lateral line $1\frac{1}{2}$ in straight part. Scutes about 75. Scutes about six times as high as broad in the center of the straight part of lateral line. Dorsal soft rays 25 to 30. Anal soft rays 24 to 26.

TYPE.—No. 7351, The American Museum of Natural History; 95 mm. to base caudal; Orient, Long Island; Roy Latham; September 19, 1919.

Range.—Atlantic coast of America. Rare. Young numerous in the Gulf Stream, off the Florida Keys (February 23, 1910).

Trachurus capensis Castelnau

Trachurus capensis CASTELNAU, 1861, Mémoire sur les poissons de l'Afrique australe, p. 43.

Range.—Cape Region of Africa. Abundant.

Trachurus japonicus (Temminck and Schlegel)

Caranx trachurus japonicus TEMMINCK and SCHLEGEL, 1844, Pisces, in Fauna Japonica, p. 109, Pl. LIX, fig. 1.

Range.—Japanese and adjacent seas.

Trachurus mccullochi, new name

Trachurus declivis McCULLOCH, 1915, Report on some Fishes, etc., Australia, Fisheries, III, p. 125, Pl. xxxiv. South Australia.

Range.—Australian seas.

Trachurus mediterraneus (Steindachner)

Caranx trachurus var. *mediterranea* STEINDACHNER, 1868, Sitzb. Akad. Wiss. Wien, LVII, part 1, p. 383. Mediterranean.

Range.—Mediterranean, occasional in the Atlantic.

Trachurus murphyi, new species

Trachurus symmetricus EVERMANN and RADCLIFFE, 1917, Bull. U. S. Nat. Mus., No. 95, p. 59, Pl. v. Peru.

Accessory lateral line ending under front of soft dorsal. Depth to base of caudal 3.87 to 4.48. Arc of curve of lateral line 1.0 to 1.1 in straight part. Scutes 94 to 101

(usually about 95). Scutes about seven times as high as broad in the center of straight part of lateral line. The anterior scutes from $\frac{3}{4}$ as high to as high as the posterior. Dorsal soft rays 32 to 33. Anal soft rays 27 to 29.

Type.—No. 7259, The American Museum of Natural History; Central Island of the Chinchas, Peru; R. C. Murphy; October 27, 1919.

Range.—Western coast of South America.

Trachurus declivis (Jenyns)

Caranx declivis JENYNS, 1842, Zoology of the 'Beagle,' Fishes, p. 68, Pl. xiv. Australia.

Trachurus novæ-zelandiæ Hutton. McCULLOCH, 1915, Report on Some Fishes, etc., Australia, Fisheries, III, p. 123, Pl. xxxiv.

Range.—Australian seas.

Trachurus picturatus (Bowdich)

Seriola picturata BOWDICH, 1825, Excursion to Madeira, p. 123, fig. 27. Madeira.

Range.—Islands of the eastern Atlantic; coast of southwest Europe (Lütken).

Trachurus symmetricus (Ayres)

Caranx symmetricus AYRES, 1855, Proc. Cal. Ac. Nat. Sci., I, p. 62. San Francisco.

Range.—Off the southwest coast of North America, north to San Francisco.

KEY

1. Body comparatively deep and compressed, the depth $3\frac{3}{4}$ to $4\frac{1}{2}$ in length to base of caudal.....2.
Body elongate, little compressed, the depth $4\frac{1}{3}$ or more in length.....7.
2. Scutes 70 or 80 (68 to 92) in number.....3.
Scutes 94 to 101 in number.....*murphyi*.
3. Chord of curve of lateral line $1\frac{1}{3}$ to $1\frac{2}{3}$ in straight part.....4.
Chord of curve of lateral line 1.2 in straight part; depth 4.1; upper accessory lateral line to front of soft dorsal only; scutes 79 to 92; height 4 or 5 times their length; dorsal with about 28, anal about 26 soft rays....*mediterraneus*.
4. Depth about 3.6 or 3.7; scutes about 75 to 77, about 6 or 7 times as high as long in center of straight part of lateral line; dorsal with 25 to 30¹, anal 24 to 28 soft rays¹.....5.
Depth 3.8 to 4.2; upper, accessory, lateral line to front of soft dorsal only (not described in *mccullochi*); height of scutes 4 or 5 times their length; dorsal with 30 to 34 soft rays, anal with 26 to 31.....6.
5. Accessory lateral line continuous under soft dorsal.....*semispinosus*.
Accessory lateral line to under front of soft dorsal only.....*lathamii*.

¹*Capensis* probably comes here. Flexure of lateral line less abrupt; scutes 65 to 75.

6. Bend in lateral line abrupt, scutes 68 to 75. *mccullochi*.
 Bend in lateral line not particularly abrupt, scutes 72 to 80. *japonicus*.
7. Chord of curve of lateral line $1\frac{1}{3}$ in straight part; upper, accessory, lateral line continuous under soft dorsal; height of central-posterior scutes 6 or 7 times their length; depth about 4.7; scutes about 75; dorsal with about 29, anal about 28 soft rays. *trachurus*.
 Chord of curve of lateral line scarcely if at all shorter than straight part; upper, accessory, lateral line to front of soft dorsal only (not described for *declivis*). 8.
8. Scutes 81 or 82 (74 to 85); anterior and posterior portions of lateral line horizontal, connected by a short oblique portion; depth about 4.5; dorsal with 30 to 35, anal 28 to 30 soft rays; height central-posterior scutes 6 or 7 times their length. *declivis*.
 Scutes 96 or 99 (90 to 108); depth 4.5 to 4.7; dorsal with 31 to 33, anal 27 to 29 soft rays. 9.
9. Anterior scutes $\frac{3}{4}$ as high to as high as posterior, the height of which (centrally) is 5 to 7 times their length. 10.
 Anterior scutes narrow, $\frac{1}{2}$ or less as high as posterior, the height of which (centrally) is 4 or 5 times their length. *symmetricus*.
10. Slender. Depth 4.5 or more. *picturatus*.
 Less slender. Depth less than 4.5. *murphyi*.

**Article XIV.—REPORT ON THE LEPIDOPTERA OF THE
AMERICAN MUSEUM EXPEDITION TO ARIZONA, 1916**

GEOMETRIDÆ AND EPIPLEMIDÆ¹

BY WM. S. WRIGHT

The material reported on here was collected by Dr. Frank E. Lutz in 1916, as a part of the entomological survey of Western United States that is being conducted by the Department of Invertebrate Zoology of The American Museum of Natural History. Dr. Lutz was accompanied by Mr. J. A. C. Rehn of the Philadelphia Academy of Natural Sciences, and a part of the material is deposited in that institution.

Most of the specimens were taken at night on or in a cheese-cloth tent that was illuminated by two gasolene lanterns. The collecting stations are all in Pima County, their location is approximately as follows:

	Latitude	Longitude	Altitude
Bear Wallow, Santa Catalina Mountains.	32° 25.3' N.	110° 44' W.	About 8000 feet
Bear Wallow Trail, Santa Catalina Mountains.	32° 22' N.	110° 46.5' W.	About 3800 feet
Sabino Basin, Santa Catalina Mountains.	32° 22' N.	110° 46.5' W.	About 3800 feet
Mud Springs, Pine Canyon, Santa Catalina Mountains.	32° 23.3' N.	110° 45' W.	About 6500 feet
Lowell Ranger Station, Santa Catalina Mountains.	32° 18.5' N.	110° 49' W.	About 2700 feet
Kits Peak Rincon, Baboquivari Mountains.	31° 57' N.	111° 33' W.	About 4050 feet
North Side Kits Peak, Baboquivari Mountains.	32° 0' N.	111° 36' W.	About 3600 feet
Coyote Mountains.	31° 58' N.	111° 29' W.	About 3500 feet
Comobabi Mountains.	32° 2' N.	111° 45' W.	About 3425 feet
Santa Cruz Village, Comobabi Mountains.	32° 1' N.	111° 54' W.	About 3100 feet
Palo Alto Ranch, Altar Valley.			
Robles Ranch, Altar Valley.	32° 5' N.	111° 18' W.	
Black Dike Prospect, Sierritas.	31° 56' N.	111° 16' W.	About 3750 feet
Lincoln Mine, Sierritas.			
San Xavier Mission, near Tucson.			

¹The following new names are proposed in this paper:
Hydriomena clarki, new species.
Euchlana lutzii, new species.

This collection seems to me rather remarkable in that the species obtained from the above localities are chiefly those characteristic of the dry, mountainous regions of the southwestern United States. The approach to what I have considered as distinctively Mexican forms is conspicuously absent, although much of the material came from near the Mexican border. In only one species, *Hydriomena clarki*, does a distinctively Mexican group seem to be represented, and even this is closely allied to one of the groups in our own fauna.

In most cases the amount of material taken has been ample for purposes of identification and, for the most part, it is in very good condition.

I wish to acknowledge the helpfulness of Mr. F. E. Watson, and to Dr. Lutz I extend my heartiest thanks for courtesies offered.

GEOMETRIDÆ

Nemoria pistaciaria Packard.

One specimen, Mud Springs, July 17-20.

Nemoria junctolinearia Græf.

One specimen, Bear Wallow, July 13.

Nemoria festaria Hulst.

One specimen, Sabino Basin, July 8-12.

Synchlora liquoraria Guenée.

One specimen, Kits Peak Rincon, July 31-August 3.

Dichorda phoenix Prout.

Two specimens, Kits Peak Rincon, August 1-4.

Mesothea viridipennata Hulst.

Three specimens, Sabino Basin, August 15-21.

Chlorochlamys masonaria Schaus.

Two specimens, Sabino Basin, August 15-21.

Dasycosymbia gracilata Grossbeck.

Three specimens, Coyote Mountains, August 3-7.

Pigia multilineata Hulst.

Twenty-eight specimens: 2, Coyote Mountains, August 3-7; 17, Sabino Basin, 6, July 8-12 and 11, August 15-21; 6, Kits Peak Rincon, July 31-August 4; 3, Comobabi Mountains, August 9-11.

The individuals taken at Sabino Basin, July 8-12, are old and worn and probably represent an earlier generation.

Dystroma species, unknown.

Two specimens, Bear Wallow Trail, July 13 and August 17-19.

The July specimen was swept from *Ceanothus*.

Hydriomena clarki, new species

Palpi extending beyond the head a distance equal to length of head, porrect and beak-like, black at tips and along sides; red-brown mixed with black above and lighter beneath. Front and occiput brownish gray with a very narrow blackish line along the middle. Thorax brownish gray with a mixture of black scales. The lappets black with brownish and white scales. A large brownish and gray tuft at the base. Abdomen rather robust, gray with a distinct reddish cast, a dark brown dorsal line. Anal tuft large and becoming ochreous at the tips.

Primaries.—The whole wing has a faint olive cast. The inner edge from the median vein is tinged with red, more pronounced just inward from the anal angle; the linear discal dot also has a reddish cast. The basal area to about one-fourth out is pale gray more or less strigate with black scales; a squarish black spot at the extreme base of this area showing most strongly at the juncture of the median and subcostal veins. The inner edge of the basal area is very narrowly black with a few white scales outwardly. Beyond is a black band half as wide as the basal area, a little wider on the costa, extending slightly outward across the wing to a deep black rectangular spot between vein one and the inner margin; the outer edge of this band is more or less sinuate with a rather sharp angle inward from costa to subcosta and an outward scallop to middle of cell. Succeeding this band is a narrow gray band determined outwardly by a fine black line which begins in a spot on the costa as wide as the band and parallels the black band across the wing; the line is lost between veins one and two but reappears between vein one and the margin. The median space is gray, conspicuously strigate with black scales; an outwardly oblique, black, scalloped line starts on the costa above the end of the cell and terminates in a black cloud above vein four. A submarginal dark liver-colored band begins on the costa midway between the cell and the apex running in an irregular course across the wing, the inner edge of this band is scalloped inwardly and the outer edge is scalloped outwardly. From costa to vein five it is about the width of the basal black band, at vein five it suddenly contracts on the inner side to about one-third the width above, runs parallel to the outer margin, gradually widening to the middle of the space between veins one and two whence it contracts again slightly to just inside the anal angle. Marginal space reddish with a deep black apical cloud cutting it above vein six. Terminal line broad and blackish, irregularly and broadly dentate. Fringe short and lustrous. All veins more or less outlined with black.

Secondaries.—Smooth, fuscous, slightly darker at outer margin; fringe somewhat lighter, lustrous.

Beneath gray, more or less irrorate with black. Apical portion of primaries cloudy and a few whitish marks on the costa.

Expanse, 32 mm.

Holotype: male; Bear Wallow, August 17–19. Amer. Mus. Nat. Hist. Coll.

Paratypes: 5 males; four with the same data as the holotype, one (left wings badly rubbed) from Sabino Basin, August 15–21. Amer. Mus. Nat. Hist. and author's collection.

The form of maculation seems to place this species in the same group as *furcata* Thunberg but the form of the uncus fixes it in the same group as *speciosata* Packard, to which species it seems to be most closely allied. I take pleasure in dedicating this species to Mr. B. Preston Clark whose generosity made the expedition possible.

Hydriomena neomexicana Hulst.

Seven specimens: 6, Coyote Mountains, August 3-7; 1, Comobabi Mountains, August 9-10.

Cœnocalpe aurata Grote.

Three specimens, Bear Wallow Trail, July 13.

Mesoleuca interrupta Grossbeck.

One specimen, Bear Wallow, July 12-17.

Eupithecia subcolorata Hulst.

One specimen, Mud Springs, July 17-20.

Eupithecia flavigutta Hulst.

Two specimens: 1 Mud Springs, July 17-20; 1, Bear Wallow Trail, July 13.

Eupithecia species, unknown.

One specimen, Coyote Mountains, August 3-7.

Eupithecia species, unknown.

Two specimens, Mud Springs, July 17-20.

Fernaldia fimetaria Grote and Robinson.

Thirty-five specimens: 3, Palo Alto, July 29-30; 21, Black Dike Prospect, July 26-29; 4, Comobabi Mountains, Aug. 9-10; 1, Lincoln Mine, July 19; 3, Kits Peak Rincon, July 31-Aug. 4; 1, North Side Kits Peak, Aug. 7-9; 1, Santa Cruz Village, Aug. 10-12, 1, Robles Ranch, Aug. 13.

Fernaldia partitaria Grote.

Seven specimens: 2, Comobabi Mountains, Aug. 9-10; 4, Black Dike Prospect, July 26-29; 1, Santa Cruz Village, Aug. 10-12.

Chloraspilates bicoloraria arizonaria Grote.

Thirty-seven specimens: 13, Kits Peak Rincon, July 31-Aug. 4; 17, Coyote Mountains, Aug. 3-7; 4, North Side Kits Peak, Aug. 7-9; 2, Comobabi Mountains, Aug. 9-10; 1, Black Dike Prospect, July 26-29.

Macaria simulata Hulst.

One specimen, Sabino Basin, Aug. 15-21.

Macaria pictipennata Hulst.

Two specimens, Kits Peak Rincon, Aug. 1-4.

Macaria s-signata Packard.

Eight specimens: 7, Kits Peak Rincon, July 31-Aug. 4; 1, North Side Kits Peak, Aug. 7-9.

Sciagraphia colorata Grote.

Twenty-six specimens: 1, North Side Kits Peak, Aug. 7-9; 4, Kits Peak Rincon, July 31-Aug. 4; 1, Sabino Basin, July 8-12;

4, Coyote Mountains, Aug. 3-7; 1, San Xavier Mission, July 24; 4, Santa Cruz Village, Aug. 10-12; 11, Tucson, 2, July 3-5 and 9, July 21-23.

Cymatophora minuta Hulst.

Three specimens: 1, Lowell Ranger Station, July 6-20; 2, Bear Wallow, July 12-17.

Phasiane tenebrosata Hulst.

Sixty-nine specimens: 58, Sabino Basin, Aug. 15-21; 11, Kits Peak Rincon, July 31-Aug. 4.

Itame octolineata Hulst.

One specimen, Black Dike Prospect, July 26-29.

Catopyrha species, unknown.

One specimen, Sabino Basin, Aug. 15-21.

Tornos scolopacinaris Guenée.

One specimen, North Side Kits Peak, Aug. 7-9.

Tornos erectarius Grossbeck.

One specimen, Coyote Mountains, Aug. 3-7.

Glaucina escaria Grote.

Two specimens: 1, Santa Cruz Village, Aug. 10-12; 1, Kits Peak Rincon, Aug. 1-4.

Glaucina erroraria Dyar.

Eight specimens: 5, Coyote Mountains, Aug. 3-7; 1, Kits Peak Rincon, July 31-Aug. 3; 1, Santa Cruz Village, Aug. 10-12; 1, Lowell Ranger Station, July 6-20.

The close distinctions necessary to separate the species of *Glaucina* make certainty of identification next to impossible unless the types, or at least compared specimens, are before us. In the case of *erroraria* Dyar, as here identified, neither the types nor compared specimens are at hand. However, the excellent paper by Grossbeck seems to make it quite clear that the specimens here listed are the true *erroraria*.

Glaucina eupetheciaria Grote.

Twenty-eight specimens: 7, North Side Kits Peak, Aug. 7-9; 1, Coyote Mountains, Aug. 3-7; 1, Black Dike Prospect, July 26-29; 1, San Xavier Mission, July 24; 18, Kits Peak Rincon, July 31-Aug. 3.

The eighteen specimens from Kits Peak Rincon seem to me to be slightly different in wing form from the rest. The apex is somewhat more produced than in the others of the series. It is quite possible, I think, that these are the typical *eupetheciaria* Grote while the rest having the apex more rounded may be referable to *pygmeolaria* Grote.

This apparent difference is hardly sufficient to separate the two species, hence they are here listed as one.

***Glaucina* species, unknown.**

Six specimens: 2, Coyote Mountains, Aug. 3-7; 1, North Side Kits Peak, Aug. 7-9; 1, Lowell Ranger Station, July 6-20; 1, Kits Peak Rincon, July 31-Aug. 3; 1, Palo Alto, July 29-30.

I am unable to definitely locate any of these specimens. They seem to represent about four species.

***Conocharis ochrofuscaria* Grote.**

Twenty-three specimens: 20, Coyote Mountains, Aug. 3-7; 1, Black Dike Prospect, July 26-29; 2, Santa Cruz Village, Aug. 10-12.

The specimens here identified as *ochrofuscaria* Grote are quite markedly darker than the specimens so identified by Grossbeck in the Museum Collection; structurally, however, they seem to be identical and I feel quite certain that my identification is correct.

***Conocharis macdunnoughi* Grossbeck.**

Eleven specimens: 8, Coyote Mountains, Aug. 3-7; 1, North Side Kits Peak, Aug. 7-9; 1, Santa Cruz Village, Aug. 10-12; 1, Kits Peak Rincon, Aug. 1-4.

The specimens here identified as *C. macdunnoughi* Grossbeck agree in all essential points with Grossbeck's description but, as I have been unable to compare them with the types, I may be in error. The species seems very close to *ochrofuscaria* Grote, but the presence of the distinct cross-lines and the darkened median space sets it off from the latter species. Barnes and McDunnough have referred *macdunnoughi* to *Glaucina*; this I believe to be in error, since *macdunnoughi* and *ochrofuscaria* are structurally identical.

***Synglochis perumbraria* Hulst.**

Ten specimens: 4, Santa Cruz Village, Aug. 10-12; 1, Marathon, Brewster County, Texas, July 1-2, '16; 3, Coyote Mountains, Aug. 3-7; 2, Kits Peak Rincon, Aug. 1-4.

***Cleora obliquaria* Grote.**

Twenty-four specimens: 3, Black Dike Prospect, July 26-29; 10, North Side Kits Peak, Aug. 7-9; 3, Santa Cruz Village, Aug. 10-12; 2, Kits Peak Rincon, July 31-Aug. 4; 5, Coyote Mountains, Aug. 3-7; 1, Palo Alto, July 29-30.

***Cleora* species (near *pampinaria* Guenée).**

One specimen, Sabino Basin, July 8-12.

***Cleora* species, unknown.**

One specimen, Kits Peak Rincon, Aug. 1-4.

Cleora species, unknown.

One specimen, Bear Wallow, July 12-17.

Alcis haydenata Packard.

Two specimens, Sabino Basin, July 8-12 and Aug. 15-21.

Stergamataea dolliata Grossbeck.

One specimen, Sabino Basin, July 8-12.

Phaeoura mexicanaria Grote.

One specimen, Sabino Basin, Aug. 15-21.

Graefia smithi Pearsall.

Two specimens, Santa Cruz Village, Aug. 10-12.

Metrocampa perlata Guenée.

Two specimens, Bear Wallow, July 12-17.

***Euchlana lutsi*, new species**

Palpi.—Sprinkled with light brown along the sides. Front light brown and concolorous with the thorax. Abdomen somewhat lighter than thorax, more ochreous; tips slightly tufted.

Primaries.—General aspect from base to outer line pale ochreous, the color deepening slightly in the apical region. Basal third strigate and clouded with olive-brown scales and patches outwardly to a broadly diffuse line of the same color crossing the wing in a wide outward curve just before the juncture of vein two with the cell. The median space is divided approximately in the center by an irregular and broadly diffused line similar to the one just described; a few brown scales are scattered over the space and the brown discal dot is fused with the line. The outer line is sharply defined, narrow and distinctly brown. This line parallels the margin except near the apex where it forms a sharp angle to the costa. Beyond and above this angle apically the ground-color appears much clouded; the rest of the space beyond the line to the outer margin is evenly chocolate-brown. Apex slightly falcate; margin broadly angled at vein four.

Secondaries.—Concolorous; basal half without lines. Just beyond the discal dot and between it and the inner margin is a straight, broadly diffused, smoky line or band. Marginal space as in primaries.

Beneath much as above but somewhat lighter.

Female.—Ground-color a little lighter than in the male, more inclined to pale ochreous with smoky brown scales and patches scattered over the entire surface, lines or bands but faintly indicated. Discal dot distinct on the primaries but obsolete on the secondaries.

Expanse, 25 mm.

Holotype: male; Coyote Mountains, Aug. 3-7. Amer. Mus. Nat. Hist. Coll.

Allotype: female; Baboquivari Mountains, Pima County, July 15-30, 1903, (O. C. Poling, Grossbeck Coll.). Amer. Mus. Nat. Hist. Coll.

Paratypes: males; 2 specimens with same data as allotype; 2 specimens, Coyote Mountains, Aug. 3-7; 2 specimens, Sabino Basin, Aug. 15-21. Amer. Mus. Nat. Hist. and author's collection.

Five of these specimens were taken by Dr. F. E. Lutz during the summer of 1916, the other three were found in the Grossbeck Collection without a name. It was quite evident that Grossbeck had given them some study and had intended describing them. The species is interesting from the fact that the amount and depth of coloration varies so considerably. One of the paratypes, slightly larger (27 mm.), is almost as devoid of distinctive lines or bands as is the allotype. There is a bare possibility that the species has been described from Mexico but I believe it to be new, hence I propose the name *lutzi* as an expression of the regard in which I hold the collector.

Epiplatymetra lentifuata Barnes and McDunnough.

One specimens, Bear Wallow Trail, July 17.

Stenaspilates albomacularia Hy. Edwards.

Six specimens: 3, Coyote Mountains, Aug. 3-7; 2, North Side Kits Peak, Aug. 7-9; 1, Black Dike Prospect, July 26-29.

Stenaspilates levisaria Grossbeck.

One specimen, Coyote Mountains, Aug. 3-7.

Stenaspilates flavisaria Grossbeck.

One specimen, Coyote Mountains, Aug. 3-7.

Gonodontis distycharia Guenée.

One specimen, Sabino Basin, Aug. 15-21.

Epiplemidæ

Callizsia certiorata Pearsall.

Ten specimens: 8, Bear Wallow Trail, July 13; 2, Mud Springs, July 17-20.

Article XV.—NOTES ON THE DISTRIBUTION AND BIBLIOGRAPHY OF NORTH AMERICAN BEES OF THE FAMILIES APIDÆ, MELIPONIDÆ, BOMBIDÆ, EUGLOSSIDÆ, AND ANTHOPHORIDÆ

BY FRANK E. LUTZ AND T. D. A. COCKERELL

CONTENTS

	PAGE
Introduction.....	491
Apidæ.....	492
Meliponidæ.....	492
Bombidæ.....	502
Euglossidæ.....	544
Anthophoridæ.....	549
Centrinæ.....	549
Anthophorinæ.....	569
Eucerinæ.....	593
Bibliography.....	629
Addendum.....	641

INTRODUCTION

It was our original intention to prepare a simple check-list of North American bees, but the literature is so scattered and a locality record without a knowledge of the authority upon which it is based is so unsatisfactory that we decided to include our bibliographic notes (especially on papers published after 1896) and to publish at present only the records for certain families of higher bees. These notes are not intended to be a complete bibliography of the subject. In general, we have not given a reference unless it added to our knowledge of distribution, and, in summarizing a reference, we have usually left out the parts that are repetitions or mere confirmations of previously published data. We think our records are practically complete up to at least 1919. No taxonomic name is given with a reference if the author used the one adopted by us here. A type locality is designated by an asterisk. It would have delayed too greatly the publication of this list to have attempted gathering unpublished records from specimens in various collections. The American Museum of Natural History would, however, be glad to have copies of such records.

Distribution is not merely spatial; distribution in time is also important. For that reason we have, for the most part, included the months (indicated by Roman numerals) in which adults were found and,

because it also is often important, the flowers at which they were captured. Doubtless some of the papers dealing with flowers and bees have been overlooked.

Since the collector has often worked harder than the author, he is entitled to have part of the credit for a new locality record. Furthermore, the collector's name, through a knowledge of his activities, sometimes enables subsequent authors to locate, at least approximately, a place which may not appear on maps. We have, therefore, usually given the collector's name (in parentheses), unless he happened to be also the author, but, unfortunately, these did not always get in our notes and it did not seem to be worth while rechecking all the references for this point alone.

The classification of bees is not in a very satisfactory shape and some of the recent changes in names and system do not seem to have helped matters a great deal. More field-work and detailed studies of comparative anatomy are needed before we can hope to accomplish much in the way of improving the taxonomy. We have, therefore, been conservative, even where we feel that changes might be justified, and we have usually "lumped" rather than "split." However, in most cases the bibliography clearly shows where splits have been made.

APIDÆ Leach

As restricted here, this family includes only *Apis*.

APIS Linnæus, 1758, pp. 343 and 575

(Type: *mellifera* Linnæus)

There are no native species in America. The introduced *mellifera* now occurs in nearly all civilized regions. *A. mellifera ligustica* Spinola, 1806, p. 35, with largely rufofulvous abdomen, is commonly kept in the United States. *A. mellifera lamarckii* Cockerell, 1906b, p. 166, (n. n. for *fasciata* Latreille, 1804, p. 171, not Linnæus, 1767) was recorded from Canyon City, Colorado, by Uhler, 1877, p. 783. Friese, 1906a, p. 299, recorded *A. mellifera syriaca* Buttel-Reepen from San José, Costa Rica.

Apis bostoniana Sulzer is neither American nor *Apis*, but is the European *Bombus hypnorum* (Linnæus). See Cockerell, 1906, p. 104.

Apis grissipes Turton, Syst. Nat. III, p. 559, from "S. American Is." (presumably West Indies) cannot be identified.

MELIPONIDÆ

We use this name for the genera which are usually grouped as the Meliponinæ of the Apidæ. They are certainly as distinct from *Apis* as is *Bombus*.

MELIPONA Illiger, 1806, p. 157(Type: *Apis favosa* Fabricius)

Dalla Torre, 1896, p. 574, includes *Trigona* Jurine and *Tetragona* Lepeletier as subgenera. Von Ihering, 1903, gives full notes on the biology of Brazilian species. Cockerell, 1919, pp. 194-206, gives a key to the species in U. S. National Museum.

amalthæa. See *Trigona*.

bipunctata. See *Trigona*.

carrikeri. See *marginata carrikeri*.

citriperda. See *Trigona ruficrus*.

costaricensis. See *fasciata costaricensis*.

cressoni. See *Trigona nigra*.

fasciata Latreille, 1811, pp. 173, 291. ♀. Vera Cruz, MEXICO.

Gronen, 1881, p. 331. Biology

Cockerell, 1919, p. 198. Pará, BRAZIL.

fasciata costaricensis Cockerell, 1919, p. 198. ♀. Pozo Azul, COSTA RICA; VI; (Carriker).

fasciata melanopleura Cockerell, 1919, p. 201. ♀. Pozo Azul, COSTA RICA; VI; (Carriker).

fasciata panamica Cockerell, 1919, p. 198. ♀. Porto Bello*, Cabima, and Alhajuelo, PANAMA; II, V; (Busck).

flavipennis Smith, 1854, p. 406. ♂. Pará, BRAZIL.

M. tilania Gribodo, 1893, p. 251. ♀. Rioja, ARGENTINA.

M. tilania Ducke, 1902, p. 294. At *Solanum toxicarium*.

Schultz, 1904, p. 816. DUTCH GUIANA. Palmar and Archidona, ECUADOR; (Hänsch).

Cockerell, 1919, p. 205. Mapiri, BOLIVIA. Guayaquil, ECUADOR. Pozo Azul, (Carriker), and Juan Vinas, (Schaus), COSTA RICA.

fulvipeda. See *fulvipes*.

fulvipes Guérin, 1839, p. 462. ♀, ♂. CUBA.

Melipona zonulata [Klug] Spinola, 1840, p. 123. MEXICO.

Apis (*Melipona*) *fulvipes* Blanchard, 1849, Plate CXXIX, fig. 7.

Trigona fulvipeda Poey. 1851, pp. 122-176. ♂ and biology. Discussed by Müller, 1875, p. 291.

Smith, 1863, Plate xx.

Fox, 1891, p. 348. Kingston, JAMAICA.

du Buysson, 1901, p. 153. Zacualco, Jalisco, MEXICO. Biology.

Cockerell, 1912b, p. 315. Gualan and Quirigua, GUATEMALA; II; at *Solanum* and *Pontederia cordata*; (W. P. Cockerell).

Friese, 1916, p. 299. San José, COSTA RICA; (Schmidt).

Variety *a* Cockerell, 1919, p. 200. ♀. Quirigua, (W. P. Cockerell), Cacao, and Trece Aguas, (Goll), GUATEMALA; V. Prinzapolca River, east coast of

NICARAGUA.

Cockerell, 1919, p. 201. Rio Jacinto, D. F., (Riquelme), and Izamal, Yucatan, (Townsend), MEXICO. Belize, HONDURAS. Puntarenas, COSTA RICA; (Knab). San Diego, (Palmer and Riley), and Guantanamo, CUBA.

fulvipes obscuripes Friese, 1916, p. 348. (*Trigona*) ♀. San Carlos, COSTA RICA; (Burgdorf). MEXICO.

fuscata Lepeletier, 1836, p. 424. ♀. PERU.

Spinola, 1840, p. 130. FRENCH GUIANA.

Trigona fuscata Smith, 1854, p. 413.

Ducke, 1902, p. 295. Belem, Pará, BRAZIL.

Schultz, 1904, p. 817. Itaituba and Tapajoz, BRAZIL; VIII, X.

Friese, 1916, p. 299. San Carlos, COSTA RICA; (Burgdorf).

Cockerell, 1919, p. 205. Mapiri, BOLIVIA.

fuscipes Friese, 1900a, p. 382. ♀, ♂. MEXICO. COLOMBIA. VENEZUELA. Yquitos, PERU. Prov. Pianhy, BRAZIL.

Zabriskie, 1909, p. 48. Description of wax.

Cockerell, 1919, p. 203. Cacao, Trece Aguas, Alta Vera Paz, GUATEMALA; V; (Goll.).

jenningsi. See *orbignyi jenningsi*.

lautipes. See *variegatipes lautipes*.

ligata Say, 1837, p. 415. (*Trigona*) ♀. MEXICO.

Cockerell, 1904a, p. 23. San Rafael, Vera Cruz, MEXICO; VII; at *Cordia*; (Townsend).

marginata carrikeri Cockerell, 1919, p. 198. ♀. Pozo Azul, COSTA RICA; VI; (Carriker).

marginata torrida Friese, 1916, p. 348. ♀. San José, COSTA RICA; (Schmidt).

melanopleura. See *fasciata melanopleura*.

nigripes Friese, 1900a, p. 381. ♀. GUATEMALA; (Stoll).

obscuripes. See *fulvipes obscuripes*.

orbignyi jenningsi Cockerell, 1919, p. 199. ♂. Las Cascadas, Canal Zone, PANAMA; (Jennings).

panamica. See *fasciata panamica*.

solani Cockerell, 1912b, p. 315. ♀. Quirigua, GUATEMALA; II; at *Solanum*; (W. P. Cockerell).

torrida. See *marginata torrida*.

titania. See *flavipennis*.

variegatipes Gribodo, 1893, p. 254. ♀, ♂. GUADELOUPE.

Crawford, 1914, p. 131. DOMINICA; (Foote).

Cockerell, 1919, p. 204. MONTSERRAT; (Riley).

variegatipes lautipes Cockerell, 1919, p. 204. ♀. MONTSERRAT; III; (Riley).

zonulata. See *fulvipes*.

Oxytrigona Cockerell

See *Trigona*.

Tetragona Lepeletier

See *Melipona* and *Trigona*.

TRIGONA Jurine, 1807, p. 245

(Type: *Apis amalthea* Olivier)

Dalla Torre, 1896, pp. 574-585, included all the previously described species under *Melipona*. Von Ihering, 1903, gives full notes on biology of Brazilian species.

Tetragona Lepeletier, 1825, p. 170, is a subgenus.

Oxytrigona Cockerell, 1917*d*, p. 124, was proposed as a subgenus with *mediorufa* as the type.

amalthea Olivier, 1789, p. 78. (*Apis*)

Melipona amalthea Illiger, 1806, p. 156.

Trigona amalthea Jurine, 1807, p. 246.

Lepeletier, 1825, p. 610. Only the biology; otherwise *T. silvestriana* Vachal.

Trigona fuscipennis Friese, 1900*a*, p. 385. ♀. GUATEMALA. COLOMBIA. Blumenau, Para, BRAZIL. PANAMA. MEXICO.

Trigona fuscipennis Ducke, 1903, p. 314. Throughout the state of Pará, BRAZIL.

See Von Ihering, 1903, p. 204 (biology, etc.) and Schultz, 1904, p. 826.

Cockerell, 1912, p. 60. BRAZIL: Natal, Rio Grande do Norte; Independencia, Parahyba; Manaus, Amazonas; VI, VIII; (Mann and Heath).

Cockerell, 1912*b*, p. 314. Gualan, Puerto Barrios, and Quirigua, GUATEMALA; II; at *Calopogonium caeruleum* and *Pontederia cordata*.

Cockerell, 1913, p. 10. Escuintla, GUATEMALA, and Las Sabanas, PANAMA; XI, XIII; (Wheeler). "This is the *T. fuscipennis* Friese. The *amalthea* of Friese and Silvestri is *T. silvestriana* Vachal (*T. friesii* von Ihering)."

Wheeler, 1913, p. 1. Biology.

Cockerell, 1914*c*, p. 309. Guayaquil, ECUADOR; (Von Buchwald).

Schrottky, 1914, p. 219. Discusses synonymy.

Cockerell, 1916*a*, p. 3. Dunoon, BRITISH GUIANA; VII; (Gaige).

See Friese, 1916, p. 299.

Cockerell, 1920*a*, p. 465. Rockstone, Potaro Landing, and Kangaruma, BRITISH GUIANA; VII, VIII; (Lutz). Attends homopterous bark insects in Brazil.

argyrea Cockerell, 1912*b*, p. 313. ♀. Quirigua, GUATEMALA; (W. P. Cockerell). "Nest in clay bank."

atomaria Cockerell, 1917*d*, p. 217. ♀. Pozo Azul, COSTA RICA; VI; (Carriker).

bilineata Say, 1837, p. 414. ♀. MEXICO.

Ihering, 1903, p. 205. Petropolis and Itatiba, BRAZIL. Biology.

Ducke, 1902, p. 324. Pará, BRAZIL.

Cockerell, 1917*d*, p. 127. Federal District, MEXICO.

bipartita Lepeletier, 1836, p. 432. ♀. BRAZIL.

Fox, 1895, p. 272. Tepic, MEXICO.

bipunctata Lepeletier, 1836, p. 427. (*Melipona*) ♀; BRAZIL.

Smith, 1863, p. 507.¹

Strand, 1910, p. 558. Asuncion, S. Lorenzo, Villa Morra, and Trinidad, PARAGUAY; XI, XII.

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

See also Ducke, 1902, p. 319; von Ihering, 1903, p. 205; Schultz, 1904, p. 828; and Cockerell, 1917*d*, p. 125.

bipunctata luteipennis Friese, 1901, p. 382. ♀. San Carlos, COSTA RICA. See also 1916, p. 348.

bipunctata wheeleri Cockerell, 1913, p. 11. ♀. Escuintla* and Patulul, GUATEMALA; I, XII; (Wheeler).

Wheeler, 1913, p. 5. Biology.

capitata Smith, 1854, p. 409. ♀. BRAZIL.

Ducke, 1902, p. 299. Belem, Marajó Island, and Macapá, BRAZIL.

Strand, 1910, p. 558. Trinidad, PARAGUAY.

Friese, 1916, p. 299. COSTA RICA.

capitata virgilli Friese, 1901, p. 268. ♀. Blumenau, St. Catharina, BRAZIL; (Virgil).

Friese, 1916, p. 299. San Carlos, COSTA RICA; (Burgdorf).

See also Ducke, 1902, p. 299, and von Ihering, 1903, p. 207.

corvina. See *ruficrus corvina*.

cressoni. See *nigra*.

cupira Smith, 1863, p. 507. ♀. BRAZIL.

Ducke, 1902, p. 317. ♂. Pará, BRAZIL. Biology.

Ihering, 1903, p. 207. Biology.

Silvestri, 1911, pp. 65-69.

Cockerell, 1912*b*, p. 313. Amatitlan, Puerto Barrios, Guatemala City, Antigua, Gualan, and Quirigua, GUATEMALA; I, II; at *Vernonia aschenborniana* and *Ipomæa sidaefolia*; (W. P. Cockerell).

Cockerell, 1913, p. 10. Zacapa, GUATEMALA, and San José, COSTA RICA; XII; (Wheeler).

Wheeler, 1913, p. 3. Biology.

Cockerell, 1920*a*, p. 464. Pacayas, COSTA RICA; (Werckele). Cabima and Porto Bello trail, PANAMA; (Busck and Jennings).

¹ I have a specimen of *bipunctata* from F. Smith's collection, and am satisfied that it is the species which Lepeletier described.—T. D. A. C.

doederleini Friese, 1900a, p. 390. ♀. Bahia and Obidos, BRAZIL. Chiriqui, PANAMA.

dorsalis Smith, 1854, p. 411. ♀. Pará, BRAZIL. (Not of Smith, 1863, p. 510, which is *meade-waldoi* Cockerell, 1915a, p. 32.)

Melipona dorsalis Girard, 1874, p. cvi. Bahia, BRAZIL.

Von Ihering, 1903, p. 211. Biology.

Holmberg, 1903, p. 378. Chaco and Atlas Misiones, ARGENTINA.

Cockerell, 1915a, p. 30. Cincinnati Coffee Plantation, 20 miles inland from the port of Santa Marta, COLOMBIA; 5,000 ft.; VII; (Gaige). Re-description, synonymy, and biology.

Cockerell, 1917d, p. 128. Alhajuelo, PANAMA; (Busck). Guapiles, COSTA RICA; (Crawford). Secanquin, GUATEMALA; (Goll.).

droryana Friese, 1900a, p. 391. ♀, ♂. Espirito Santo, BRAZIL.

Ihering, 1903, p. 216. Biology.

Strand, 1910, p. 558. Asuncion, S. Lorenzo, Villa Morra, and Puerto Bertoni, PARAGUAY,

Cockerell, 1920a, p. 466. Acapulco, MEXICO; (Knab). Cacao, Trece Aguas, GUATEMALA; (Goll). Discuss the synonymy involving *mosquito* and *emerina*.

duponti Spinola, 1840, p. 124. Mexico. A *nomen nudum*.

fericauda Cockerell, 1917d, p. 127. ♀. Porto Bello, PANAMA; IV; (Busck).

flaveola. See *tataira friesiella*.

flaveola mediorufa Cockerell, 1913, p. 12. ♀. Escuintla, GUATEMALA; XII; (Wheeler).

Wheeler, 1913, p. 8. Biology.

flavocincta. See *frontalis flavocincta*.

friesiella. See *tataira friesiella*.

friesii. See *amalthea*.

frontalis Friese, 1911, p. 455. ♀. HONDURAS.

Cockerell, 1912, p. 50. Chinandega, NICARAGUA; (Baker).

Cockerell, 1913, p. 11. Patulul, GUATEMALA; I; (Wheeler).

Wheeler, 1913, p. 4. Biology.

Cockerell, 1914c, p. 309. Guayaquil, ECUADOR.

Cockerell, 1920a, p. 462. Guadalajara, Jalisco, MEXICO; (Diguet).

frontalis flavocincta Cockerell, 1912, p. 50. ♀. Independencia, Parahyba, BRAZIL; (Mann and Heath).

T. f. flavocincta var. *a* Cockerell, 1912b, p. 314. ♀. Quirigua, GUATEMALA; (W. P. Cockerell).

Cockerell, 1917d, p. 217. "Baker and Ashmead formerly identified as *lineata* Mexican specimens of *T. frontalis flavocincta* Ckll., an insect easily separated by the shining mesothorax."

Cockerell, 1920a, p. 462. Paraiso, Canal Zone, PANAMA; I; (Busck).

fulvipeda and *fulvipes*. See *Melipona*.

fulviventrís Guérin, 1845, p. 463. MEXICO.

Ducke, 1902, p. 312. ♀, ♂. Pará, BRAZIL.

Cockerell, 1912, p. 61. Porto Velho (This is located 7 k. N. of the old town, San Antonio, which is just below the lowest falls of the Madeira), Amazonas, BRAZIL; IX; (Mann and Baker).

Cockerell, 1912b, p. 314. Puerto Barrios, Quirigua, Amatitlan, and Guatemala City, GUATEMALA; II; at *Zerzemia virgulta*, *Ipomoea quinquefolia*, and *Pontederia cordata*; (W. P. Cockerell).

Cockerell, 1913, p. 10. Zacapa, GUATEMALA; (Wheeler).

Friese, 1916, p. 299. San Carlos, COSTA RICA; (Burgdorf).

Cockerell, 1920a, p. 461. Cacao, Tres Aguas, GUATEMALA; (Goll). San Antonio, NICARAGUA. Sonsonata, SALVADOR; (Knab). Esparta, (Knab). and Pozo Azul, (Carriker), COSTA RICA. Cordoba, Mexico; (Knab). Alafaela and Gatun, (Jennings), and Las Cruces, Porto Bello, Paraiso, Alhajuelo, and Cabima, (Busck), PANAMA.

See *laboriosa* Smith.

fuscata. See *Melipona*.

fuscipennis Friese, 1900a, p. 385. ♀. GUATEMALA. COLOMBIA. Pará and Blumenau, BRAZIL. PANAMA. MEXICO.

Ducke, 1902, p. 314. ♂.

Silvestri, 1903, p. 187. Coxipó, BRAZIL. In nests of *Eulermes rippertii* (Ramb.).

See *amalthaea* and *ruficrus corvina*.

hellwegeri Friese, 1900a, p. 389. ♀. Cuantla, Jacubaya, and Cornúvaca [Cuernavaca?], MEXICO.

jatiformis Cockerell, 1912b, p. 311. ♀. Quirigua* and Puerto Barrios, GUATEMALA; I; (W. P. Cockerell).

jaty Smith, 1863, p. 507. ♂. BRAZIL.

Ducke, 1902, p. 307. Belem, Pará, BRAZIL. See also von Ihering, 1903, p. 220; Schultz, 1904, p. 825; and Strand, 1910, p. 559.

Cockerell, 1912b, p. 312. Amatitlan and Quirigua, GUATEMALA; II; at *Zerzemia virgulta*; (W. P. Cockerell).

Cockerell, 1913, p. 10. Escuintla and Patulul, GUATEMALA; I, XII; (Wheeler).

Wheeler, 1913, p. 2. Biology.

Cockerell, 1920a, p. 461. Ollas de Moka and San José, GUATEMALA. Pozo Azul, COSTA RICA; (Carriker). NICARAGUA. Tabernilla, Canal Zone, PANAMA; (Busck).

kohli. See *pallida*.

laboriosa Smith, 1862, p. 42. ♀. PANAMA.

Cockerell, 1910b, p. 366. "A specimen from Smith's collection appears to me to be identical with *T. fulviventrís* Guér., as represented by [material collected by] Baker at Belize."

ligata. See *Melipona*.

luteipennis. See *bipunctata luteipennis*.

mayarum. See *zeigleri mayarum*.

meade-waldoi. See *dorsalis*.

mediorufa. See *flaveola mediorufa*.

mellaria. See *punctata*.

mellicolor Packard, 1869, p. 56. ♀. Between Quito and the Napo River, ECUADOR.

Cockerell, 1917*d*, p. 124. Pozo Azul, COSTA RICA; (Carriker).

mexicana Guérin, 1844, p. 464. MEXICO.

Schultz, 1904, p. 827. "Amazon," BRAZIL; (Bates).

Cockerell, 1913, p. 11. Rio Nautla, MEXICO; (Townsend).

mirandula Cockerell, 1917*d*, p. 122. ♀. Pozo Azul, COSTA RICA; VI; (Carriker).

molesta Puls. Dalla Torre, 1896, p. 581, erroneously records it from North America.

musarum Cockerell, 1917*d*, p. 123. ♀. "Philadelphia Banana R." COSTA RICA; (Knab). Boqueron River, PANAMA; V; (Busck).

Cockerell, 1920*a*, p. 464. Cotinga River, BRAZIL: 4000 feet; VIII; (Crampton). May be a subspecies of *rhumbleri* Friese.

nigerrima Cresson, 1878*a*, p. 181. ♀. MEXICO; (Sumichrast).

Cockerell, 1912*b*, p. 312. Quirigua, GUATEMALA; II; at *Pontederia cordata*, *Ipomæa sidefolia*, and *Centrosema plumieri*; (W. P. Cockerell). P. 492: Rio Charape, PERU; 5000 ft.; IX; (Townsend).

Friese, 1916, p. 299. San José, COSTA RICA; (Schmidt).

See *silvestriana*.

nigra Cresson, 1878*a*, p. 181. ♀. MEXICO; (Sumichrast).

Melipona cressoni Dalla Torre, 1896, p. 577.

Cockerell, 1913, p. 12. Belize, BRITISH HONDURAS; (Baker).

nigrita. See *pallida nigrita*.

nigrocyanæa Ashmead, 1900, p. 208. ♂. Leeward side of ST. VINCENT, W. I. (but in his list, p. 299, he gives it as from GRENADA, W. I.).

opaca Cockerell, 1917*d*, p. 126. ♂. Tabernilla, Canal Zone, PANAMA; VII; (Busck).

pachysoma Cockerell, 1917*d*, p. 125. ♀. Porto Bello*, PANAMA; (Busck). Also Culebra, Canal Zone; (Rousseau).

pallida Latreille, 1804, p. 177, Pl. XIII, fig. 14. (*Apis*) ♀. FRENCH GUIANA.

Latreille, 1809, p. 183.

Melipona pallida Lamarck, 1817, p. 53.

Trigona kohli Friese, 1900a, p. 387. ♀. COLOMBIA. PERU. FRENCH and DUTCH GUIANA. Pará, São Paulo, Manaus, BRAZIL.

Trigona kohli Silvestri, 1903, p. 187. Coxipo, Cuyaba, and Urucum, BRAZIL; in nests of *Eutermilis rippertii*.

Cockerell, 1912, p. 61. Abuná, on the Rio Madeira nearly opposite mouth of Rio Abuná, BRAZIL; IX; (Mann and Baker).

Wheeler, 1913, p. 3. Gatun, Canal Zone, PANAMA. Habits.

Cockerell, 1913, p. 10. Las Sabanas, PANAMA; XI; (Wheeler).

Cockerell, 1920a, p. 463. Rockstone, Tumatumari, Tukeit, and Kaieteur, BRITISH GUIANA; VII, VIII; (Lutz and Crampton). Tabernilla, La Chorrera, Rio Trinidad, and Alhajuelo, PANAMA; (Busck).

pallida nigrita Friese, 1901, p. 269. ♀, ♂. Cordoba, MEXICO.

panamensis. See *pectoralis panamensis*.

parastigma Cockerell, 1918, p. 165. ♀, ♂. N. n. for *stigma* Cockerell, 1912b, p. 312 (not Smith). Quirigua, GUATEMALA; (W. P. Cockerell).

Trigona stigma, Cockerell, 1913, p. 11. Las Sabanas, PANAMA, XI. Sangre Grande, TRINIDAD; III; (Scott).

Trigona stigma Wheeler, 1913, p. 5. Biology.

pectoralis Dalla Torre, 1896, p. 582. N. n. for *thoracica* Cresson, 1878a, p. 181 (not Smith). ♀. MEXICO; (Sumichrast).

Cockerell, 1913, p. 11. Escuintla, GUATEMALA, XII; (Wheeler). San Marcos, NICARAGUA; (Baker). Has been confused with *dorsalis* Smith.

Wheeler, 1913, p. 6. Biology.

See also Cockerell, 1915a, p. 31.

pectoralis panamensis Cockerell, 1913, p. 12. ♀. Las Sabanas, PANAMA; XI; (Wheeler).

Wheeler, 1913, p. 6. Biology.

perangulata Cockerell, 1917d, p. 125. ♀. Alhajuelo*, Canal Zone, PANAMA; V; (Busck). Pozo Azul, COSTA RICA; VI; (Carriker).

perilampoides. See *punctata*.

punctata Smith, 1854, p. 409. ♀. Pará, BRAZIL.

Trigona mellarius Smith, 1862, p. 40. ♀. PANAMA.

Trigona perilampoides Cresson, 1878a, p. 181. ♀. MEXICO; (Sumichrast).

Friese, 1903, p. 361. Bartica, BRITISH GUIANA.

T. mellaria Cockerell, 1911b, p. 285. Piura, PERU; IV; at asclepiads; (Townsend).

Trigona mellaria W. P. Cockerell, 1912, p. 282, and 1912b, p. 312. Gualan and Quirigua, GUATEMALA; II; at *Calopogonium ceruleum*.

Trigona perilampoides Cockerell, 1913, p. 10. Escuintla, GUATEMALA; XII; (Wheeler).

Meade-Waldo, 1913, p. 497. Synonymy.

rhumbleri. See *musarum*.

ruficrus Latreille, 1804, p. 176. (*Apis*) ♀. BRAZIL.

Melipona citriperda Illiger, 1806, p. 158.

Jurine, 1807, p. 246. ♀.

Von Ihering, 1903, p. 228. Biology.

Strand, 1910, p. 557. Asuncion, Trinidad, Villa Morra, and S. Lorenzo, PARAGUAY; XI, XII.

Cockerell, 1912, p. 60. Natal, Rio Grande do Norte, and Independencia, Parahyba, BRAZIL; VI; (Mann and Heath).

Cockerell, 1913, p. 12. Zacapa, GUATEMALA; XII; (Wheeler).

Wheeler, 1913, p. 7. Biology.

ruficrus corvina Cockerell, 1913, p. 12. ♀. Zacapa*, GUATEMALA; XII. San José, COSTA RICA; XII. Gatun, Canal Zone, XI, and Las Sabanas, PANAMA. (Wheeler).

Wheeler, 1913, p. 7. Biology.

Cockerell, 1918a, p. 482. Chagres River, Canal Zone, PANAMA; X; chewing on the leaves of young citrus plants; (Morrison).

Cockerell, 1920a, p. 465. Tumatumari, BRITISH GUIANA; VII; (Lutz).

salvatoris Cockerell, 1917d, p. 124. ♀. San Salvador, SALVADOR; VIII. Escuintla, GUATEMALA; (Knab).

schulthessi Friese, 1900a, p. 386. ♀. GUATEMALA; (Stoll).

silvestriana Vachal. Cockerell, 1912b, p. 312, says that the one reported by Vachal from British Honduras may have been *nigerrima*. See also *amalthaea*.

stigma. See *parastigma*.

tataira friesiella Cockerell, 1917d, p. 124. N. n. for *flaveola* Friese, 1900a, p. 389 (not Spinola). ♀. COLOMBIA. GUATEMALA; (Stoll). Espirito Santo, BRAZIL; (Michaëlis).

Trigona flaveola Friese, 1916, p. 299. San Carlos, COSTA RICA; (Burgdorf).

thoracica. See *pectoralis*.

townsendi Cockerell, 1911b, p. 286. ♀. Piura, PERU, X; (Townsend).

Cockerell, 1913, p. 10. Patulul, GUATEMALA; I; (Wheeler).

Wheeler, 1913, p. 5. Biology.

Cockerell, 1920a, p. 465. Boruca, COSTA RICA; VII; (Carriker). Escuintla, (Knab), and Cacao , Trece Aguas, (Schwarz and Barber), GUATEMALA. Alhajuelo, Canal Zone, PANAMA; III; (Busck).

virgilii. See *capitata virgilii*.

wheeleri. See *bipunctata wheeleri*.

zexmeniae Cockerell, 1912b, p. 313. ♀. Quirigua* and Gulan, GUATEMALA; II; at *Zexmenia virgulata* and *Vernonia aschenborniana*; (W. P. Cockerell).

ziegleri Friese, 1900a, p. 391. ♀. Amazonas and Pará, BRAZIL. VENEZUELA. PANAMA. See, also, Ducke, 1902, p. 308.

Friese, 1916, p. 299. COSTA RICA.

ziegleri mayarum Cockerell, 1912b, p. 311. ♂. Quirigua, GUATEMALA; (W. P. Cockerell.)

BOMBIDÆ

Franklin (1913 and 1913a) has given such an excellent account of the American species that we have followed him for the most part, although we do not agree entirely with his treatment of varieties.

Apathus Newman

See *Psithyrus* and *Bombus*.

Bombias Robertson

See *Bombus*.

BOMBUS Latreille, 1802a, p. 385 (in part)

(See also Latreille, 1802, p. 437. Type: *Apis terrestris* Linnæus)

Bremus (Panzer, 1801; see, also, Morice and Durrant, 1914, p. 428) is accepted by some recent authorities as the name for this genus, but the case is still debatable and it seems better to use here the well-known name.¹

Bombias Robertson, 1903, p. 176 (Type: *B. auricomus* Robertson) was proposed as a separate genus but we have followed Franklin, 1911, p. 161, in treating it as a subgenus. The subgenera may be further subdivided into "groups" as follows.

<i>Bombus</i>	<i>Bombias</i>
Dumoucheli Group	Fraternus Group
Pratorum "	Auricomus "
Kirbyellus "	
Borealis "	
Terrestris "	

See, in this connection, Radoszkowski, 1884a, pp. 51-92. The groups to which the North American species have been referred, chiefly by Franklin, 1913 and 1913a, are indicated here by initials in square brackets placed before the specific names.

Cockerell and McNary, 1902, p. 71, discuss mouth-parts in their relation to flowers.

The following names should be dropped as unrecognizable.

Apis alata Fabricius, 1798, p. 274, or *Bombus elatus* Fabricius, 1804, p. 352, may be *Apathus citrinus* Smith, 1854, p. 385—male of *Psithyrus laboriosus*.

¹I do not consider that there is any valid reason for using *Bremus*.—T. D. A. C.

Apis antiguensis Fabricius, 1775, p. 380, was probably not a *Bombus*. If it was, the "Antigua" from which it was said to have come was almost certainly not a West Indian island as no *Bombus* has been found native in any of the Antilles. There is an Antigua in Guatemala, for example.

Apis marylandica Fabricius, 1798, p. 273.

Bombus ornatus Smith, 1854, p. 398. Handlirsch thought it might be a variety of *ternarius*.

Bombus parvulus Fabricius, 1804, p. 352.

Bombus praticolus Kirby, 1837, p. 274. Friese cites "*praticola* Nyl." as a variety of *lapponicus* subsp. *lugubris*.

[T.] *affinis* Cresson, 1863, p. 103. ♀* ("♀" in error), ♂. CANADA*; (Saunders). NEW YORK; (Norton).

B. vagans Cresson, 1863, p. 91. ♀, not ♀ and ♂.

Provancher, 1888, p. 339. Ottawa, CANADA; (Guignard).

Handlirsch, 1888, p. 229. Boston, MASSACHUSETTS; (Konopitsky). GEORGIA; (Morrison).

Titus, 1902, p. 38. COLORADO.

Græniche, 1906, p. 20. Milwaukee County, WISCONSIN; at *Parnassia caroliniana*.

Græniche, 1907, p. 91. ♀. WISCONSIN; at *Ribes oxycanthoides*.

Smith, 1910, p. 698. Greenwood Lake and Westville, NEW JERSEY.

Franklin, 1913, p. 277. "It is not very common in northern NEW ENGLAND but apparently grows much more so southward. In southern New England it is quite a common species, though less so than several others. It ranges southward through to Middle Atlantic States into SOUTH CAROLINA and GEORGIA, where it again appears to be rare, and westward certainly as far as Ramsey County, MINNESOTA, and probably somewhat farther." Pittsburgh, PENNSYLVANIA. Nest.

Franklin, 1915, p. 413. Fargo, NORTH DAKOTA; (Stevens).

Viereck, 1916, p. 757. Branford, Colebrook, New Haven, and Salisbury, CONNECTICUT.

Bequaert, 1920, p. 9. Auburndale, Dedham, and Sherborn, MASSACHUSETTS; at *Ceanothus americana*.

[T.] *affinis novæ-angliæ* Bequaert, 1920, p. 6. Forest Hills* and Sherborn, MASSACHUSETTS. Brooklyn, NEW YORK. Suggests that *B. juxtus* Titus, 1902, pp. 39, 43, from Woods Hole, Massachusetts, is this variety.

alaskensis. See *flavifrons*.

alata. See p. (502.).

albertensis. See *rufocinctus*.

[P.] *alboanalis* Franklin, 1913, p. 385. ♀ or ♀. New name for the following misidentifications.

B. sitkensis Ashmead, 1902a, p. 126 (part). Kukak Bay, ALASKA; VII. Bering Island (Stejneger) and Copper Island (Barrett-Hamilton), SIBERIA.

(?) *B. sitkensis* Viereck, 1904, p. 99. Vancouver, BRITISH COLUMBIA; VI; (Harvey).

Franklin, 1913, p. 385. Kodiak and Popoff Island, ALASKA; (Kincaid).
Smith 1857, p. 30, recorded the European *hortorum* from Lake Winnepeg; it "should be referred either to this species, the locality labels of Smith's specimens having been incorrect, or possibly to *B. mixtus*."

albocaudata. See *weisi*.

[P.] *alboniger* Franklin, 1915, p. 409. ♀, ♂, ♂. Cerro Zunil, GUATEMALA; 4000–5000 ft.; (Champion). Irazu, COSTA RICA; 6000–7000 ft.; (Rogers).

alpina. See *arcticus*.

[P.] *ambiguus* Franklin, 1911, p. 159. ♀, * ♀. Sisson and Santa Cruz Mountains, CALIFORNIA. Keyport, WASHINGTON.

[D.] *americanorum* Fabricius, 1775, p. 380. (*Apis*) America.

(?) *Apis pennsylvanicus* De Geer, 1773, p. 575.

Apis nidulans Fabricius, 1798, p. 274. North America.

Fabricius, 1804, p. 346.

B. nidulans Fabricius, 1804, p. 346.

Bremus americanorum Jurine, 1807, p. 260.

Centris americanorum Lepeletier, 1825, p. 795.

Harris, 1835, p. 70. MASSACHUSETTS.

Greene, 1860, p. 172. "Western America."

B. pallidus Cresson, 1863, p. 92. ♀. St. Louis, MISSOURI; (Norton).

B. pennsylvanicus Cresson, 1863, p. 94. ♀, ♂, not the ♂. CONNECTICUT. NEW YORK. NEW JERSEY. PENNSYLVANIA. DELAWARE. MARYLAND. VIRGINIA. ILLINOIS. KANSAS. FLORIDA. TEXAS. The nest (p. 164) from Gloucester, NEW JERSEY, contained "*Apathus elatus*."

Apathus elatus Cresson, 1863, p. 114. ♂. Gives as synonyms *Apis alata* Fabricius, 1798, p. 274, and *Bombus elatus* Fabricius, 1804, p. 352.

B. pennsylvanicus Packard, 1864, p. 111. MAINE. Boston, MASSACHUSETTS.

B. pennsylvanicus Riley, 1870, p. 303. Le Roy, NEW YORK.

B. pennsylvanicus Cresson, 1872, p. 285. Bosque County (Belfrage) and Dallas County (Boll), TEXAS.

B. pennsylvanicus Cresson, 1875, p. 728. Eastern NEVADA; (Yarrow).

B. pennsylvanicus Cresson, 1876, p. 210. Davenport, IOWA; (Putnam).

Apathus elatus nidulans, *B. pennsylvanicus americanorum* and *B. p. pallidus* Cresson, 1879, p. 230.

B. pennsylvanicus Patton, 1879, p. 367. Northwestern KANSAS; IX; at *Solidago*; (Willis' on).

B. pennsylvanicus Bowles, 1880, p. 33. Montreal and Quebec, CANADA;

(Provancher).

Apathus elatus Provancher, 1882, p. 269. St. Anne de Lapérade, CANADA.

B. pennsylvanicus Handlirsch, 1888, p. 238 (part). GEORGIA.

B. pennsylvanicus Coville, 1890, p. 200. Discusses the "*elatus*" question. See also Robertson, 1890, p. 40.

Robertson, 1891a, pp. 569-597. Carlinville, ILLINOIS; at *Asclepias verticillata*, *incarnata*, *cornuti*, and *purpurescens*, *Gentiana andrewsii*, *Linaria vulgaris*, *Phlox divaricata*, *Polemonium reptans*, *Hydrophyllum virginicum* and *appendiculatum*, *Mertensia virginica*, *Ipomœa pandurata*, *Convolvulus sepium*, *Solanum nigrum* and *carolinense*, *Verbascum thapsus*, *Collinsia verna*, *Pentstemon pubescens* and *levigatus digitalis*, *Veronica virginica*, *Seymeria macrophylla*, *Gerardia pedicularia*, *purpurea*, *tenuifolia*, and *auriculata*.

Robertson, 1894, pp. 436-475. Macoupin County, ILLINOIS; at *Prunus serotina*, *Rubus villosus*, *Potentilla canadensis*, *Rosa humilis* and *setigera*, *Pyrus coronaria*, *Cralæus coccinea* and *crusgalli*, *Veronia fasciculata* (printed *noveboracensis* but changed by author in copies he sent out), *Lacinaria* ["*Liatris*"] *pycnostachya*, *Solidago canadensis*, *nemoralis*, and *lanceolata*, *Boltonia asteroides*, *Aster noveanglie* and *paniculatus*, *Antennaria plantaginifolia*, *Silphium laciniatum*, *Helianthus mollis*, *grosseserratus*, and *tuberosus*, *Verbesina helianthoides*, *Coreopsis palmata*, *tripteris*, and *aristosa*, *Bidens chrysanthemoides*, *Helinium autumnale*, and *Cnicus altissimus*, *altissimus discolor*, and *lanceolatus*.

Robertson, 1895, pp. 140-143, 145, 148. At *Gentiana puberula*, *Frasera carolinensis*, *Phlox pilosa*, *Lithospermum canescens*, *Mimulus alatus* and *ringens*.

Robertson, 1896, pp. 156, 159, 160, 162, 165, 175, 176, 178. At *Podophyllum pellatum*, *Æsculus*, *Astragalus canadensis* and *mexicanus*, *Gymnocladus canadensis*, *Aster ericoides viollosus*, *Silphium perfoliatum*, and *Rudbeckia laciniata*.

Robertson, 1896a, p. 158. At *Rhamnus lanceolata*.

Psithyrus elatus Dalla Torre, 1896, p. 569.

Cockerell, 1898d, p. 71. Mesilla Valley, NEW MEXICO.

Robertson, 1898a, pp. 230-244. At *Lespedeza reticulata*, *Cornus paniculata*, *Viburnum pubescens*, *Lonicera sullivantii*, and *Helianthus divaricatus*.

Cockerell and Porter, 1899, p. 388. Las Vegas, NEW MEXICO; VI-X; at *Cleome serrulata*; (Rishel).

Psithyrus cevallie Cockerell, 1899, p. 157. Las Cruces, NEW MEXICO; VIII; at *Cevallia sinuata*. Also Mesilla Park, NEW MEXICO; XI; at *Aster canescens viscosus*.

B. pennsylvanicus Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

B. pennsylvanicus Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

B. pennsylvanicus Meehan, 1902, p. 35. Visited blue *Lobelia syphililitica* but not scarlet *Lobelia cardinalis*.

B. titusi Ashmead, 1902, p. 50. ♂. Lamar, COLORADO; IX; (Gillette); see Titus, 1902, p. 42.

Barks, 1902, p. 212. Sleeping habits.

B. pennsylvanicus Titus, 1902, p. 42. Fort Collins, Foothills, Livermore, Virginia Dale, Julesburg, and Rocky Ford, COLORADO; VI-IX.

B. pennsylvanicus Harris and Kuchs, 1902, p. 25. St. Joseph, MISSOURI; at *Solanum rostratum*.

Viereck, 1903a, p. 119. College Park and Chestertown, MARYLAND, VI-X; (Vanatta).

B. pennsylvanicus Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VIII; (Snow).

Britton and Viereck, 1906, pp. 217, 220. At *Pyrus malus* and *Rubus nigrobaccus*.

Cockerell, 1906, p. 313. "Upper to Middle Sonoran."

B. fervidus Fairchild and Barrett, 1906, p. 13 (?; synonymy *vide* Franklin). Arlington Farm, VIRGINIA (?). Description of copulation.

Gränicher, 1907, pp. 22, 31, 40, 44, 93, 94. ♀. WISCONSIN; at *Uvularia grandiflora*, *Erythronium americanum*, *Salomonis biflora*, *Trillium erectum*, *Ribes cynosbati* and *gracile*.

Swenk, 1907, p. 296. Lincoln, Omaha, South Bend, Cedar Bluffs, Weeping Water, Nebraska City, West Point, Neligh, Broken Bow and Brown, Rock, and Hitchcock Counties, NEBRASKA; at *Astragalus*, *Rubus*, *Malus*, *Petalostemon*, *Berberis*, *Carduus*, *Cassia*, *Psoralea*, *Monarda*, *Solanum*, *Vernonia*, *Solidago*, and *Helianthus*.

Cockerell, 1907b, p. 257. Boulder, COLORADO; VIII, IX; at sunflower and *Melilotus alba*; (Weston, W. P. Cockerell, Rohwer).

B. pennsylvanicus Fletcher and Gibson, 1907, p. 129. Ottawa, ONTARIO; (Fletcher).

B. pennsylvanicus Tucker, 1909, p. 277. Wichita and Lawrence, KANSAS; V-IX.

Cockerell, 1911, p. 391. Cuttyhunk Island, MASSACHUSETTS; VII.

Gränicher, 1911, p. 249. Mouth of Yellow River in Burnett County, Hudson in St. Croix County, Prescott and Maiden Rock in Pierce County, and Fountain City in Buffalo County, WISCONSIN; VII, VIII.

B. pennsylvanicus Franklin, 1913, p. 399. Hanover, NEW HAMPSHIRE. Oaxaca, MEXICO. "Common throughout the United States, east of the Rocky Mountains, except in some of the most northern ones."

B. pennsylvanicus Franklin, 1915, p. 414. Fargo, NORTH DAKOTA; (Stevens). Jalisco, MEXICO; (Schumann).

B. pennsylvanicus Cockerell, 1917a, p. 192. San Benito, TEXAS; (W. P. Cockerell).

Cockerell, 1919c, p. 27. Boulder, COLORADO; X; at *Salvia pitcheri*.

Bequaert, 1920, p. 9. Botson, Lexington, and Sherborn, MASSACHUSETTS.

It seems that *americanorum* is a better name than *pennsylvanicus*, as the identity of the latter is too uncertain; and Franklin, after an exhaustive discussion, states that he is of the opinion "that De Geer's figure was really made from a specimen of *auricomus*." In this connection see Robertson, 1920, p. 14.

antiquensis. See p. (503).

[B.] *appositus* Cresson, 1878a, p. 183. ♀*, ♂, ♂. COLORADO.* NEW MEXICO. UTAH. NEVADA.

(?) *B. borealis* Cresson, 1876, p. 210. Empire, COLORADO.

Cockerell, 1910d, p. 128. New Castle, COLORADO; at *Carduus*; (Robbins).

Tucker, 1909, p. 277. Buffalo, COLORADO; VIII.

Franklin, 1913, p. 285. "Appears to be confined to the mountain ranges and higher lands of the western United States and to the southwestern portion of Canada (probably the lower lands)." WASHINGTON. Chino, southern CALIFORNIA. Western MONTANA. WYOMING.

Cockerell, 1915b, p. 483. Corona, COLORADO; above timber line; at *Trifolium dasycarpum*; (Kenoyer).

Sladen, 1919, p. 126. Connects *borealis* with the Eurasian *distinguendus*. See *borealis*.

[K.] **arcticus** Kirby, 1821, p. 216. ♀, ♂. Boothia Felix, ARCTIC AMERICA. (See Meade-Waldo, 1916, p. 469.)

For various probable but uncertain references in synonymy see Franklin, 1913, p. 302, and Dalla Torre, 1896, pp. 511, 524.

B. grænländicus (Westermann) Smith, 1854, p. 393, ♀. GREENLAND.

(?) *B. hyperboreus* Schmiedeknecht, 1882, p. 308. Arctic regions of EUROPE and SIBERIA.

B. hyperboreus Fox, 1892, p. 135. Disco Island, lat. 69° 10', West GREENLAND; VI, VIII; (Mengeland Hughes).

Bremus hyperboreus Frison, 1919, p. 456. 76° 30' N. to 78° 20' N.; Crocker Land Expedition. Believes that *arcticus* = *hyperboreus* Schönherr, 1809, p. 57.

Sladen, 1919a, p. 28g. ♂, ♀. Bernard Harbour, NORTHWEST TERRITORIES and Herschel Island, YUKON TERRITORY; (Johansen). Collinson Point (Johansen), Barter Island (Jenness), ALASKA; "'Cape Ross, Melville Island, Northwest Territories, by Emiu (Eskimo),' (V. Stefansson) *Bombus arcticus* is probably the *B. hyperboreus* of European authors, found in Greenland and Arctic Eurasia."

asploni. See *Psithyrus ashtoni*.

astragali. See *rufocinctus*.

atrifasciatus. See *kirbyellus*.

aztecus. See *fervidus dorsalis*.

[A.] **auricomus** Robertson, 1903, pp. 176, 177. (*Bombias*) ♀, ♂, ♂. Carlinville, ILLINOIS.

B. pennsylvanicus Cresson, 1863, p. 94. ♀ (part), ♂ (part), ♂.

B. nevadensis Handlirsch, 1888, p. 245. ♂.

B. pennsylvanicus Robertson, 1890, p. 40.

B. pennsylvanicus Robertson, 1891a, pp. 571, 573, 574, 580, 589, 591. At *Asclepias incarnata*, *cornuti*, and *sullivantii*, *Mertensia virginica*, *Collinsia verna*, and *Pentstemon lævigatus digitalis*.

B. pennsylvanicus Robertson, 1894, pp. 438-475. Macoupin County, ILLINOIS; at *Rubus villosus*, *Pyrus coronaria*, *Crataegus crusgalli*, *Vernonia fasciculata* (printed *noveboracensis* but changed by the author in copies sent out), *Eupatorium purpureum*, *Helianthus grosseserratus*, and *Cnicus altissimus*, *altissimus discolor*, and *lanceolatus*.

B. pennsylvanicus Robertson, 1895a, p. 143. At *Phlox pilosa*.

(?) *B. pennsylvanicus* Britton and Viereck, 1906, p. 213. CONNECTICUT; at *Ribes nigrum*.

Bombias auricomus Viereck, 1906, p. 240. Magdalena Mountains, NEW MEXICO; VII; (Snow).

Bombias auricomus Swenk, 1907, p. 295. Lincoln, Omaha, South Bend, West Point, and Dundy County, NEBRASKA; V-X; at *Ribes*, *Astragalus*, *Fragaria*, *Rubus*, *Antirrhinum*, and *Carduus*.

Bombias auricomus Smith, 1910, p. 699. Caldwell and Westville, NEW JERSEY.

Bombias auricomus Grænicier, 1911, p. 249. Hudson in St. Croix County and Prescott in Pierce County, WISCONSIN; VII, VIII.

B. (Bombias) auricomus Franklin, 1913, p. 413. CANADA (probably southern Ontario). NEW YORK. MASSACHUSETTS. PENNSYLVANIA. MARYLAND. DELAWARE. VIRGINIA. NORTH CAROLINA. TENNESSEE. KENTUCKY. OHIO. INDIANA. ILLINOIS. MICHIGAN. St. Paul, MINNESOTA. MISSOURI. IOWA. Greenville, TEXAS. KANSAS. Virginia Dale, COLORADO.

Bombias auricomus Viereck, 1916, p. 759. Branford, CONNECTICUT; V.

badiocollis. See *ephippiatus*.

balteatus. See *kirbyellus*.

bicolor. See *rubicundus*.

bifarius. See *edwardsii*.

[P.] *bimaculatus* Cresson, 1863, p. 92. ♂. CONNECTICUT; (Norton).

B. ridingsii Cresson, 1878a, p. 182. ♀, ♂. WEST VIRGINIA; (Ridings).

Cresson, 1879, p. 230. MASSACHUSETTS. *B. ridingsii*: CANADA.

B. ridingsii Robertson, 1891a, pp. 579, 580, 589, 594. At *Hydrophyllum virginicum* and *appendiculatum*, *Mertensia virginica*, *Collinsia verna*, and *Seymeria macrophylla*.

B. ridingsii Robertson, 1894, p. 447. Macoupin County, ILLINOIS; at *Amelanchier canadensis*.

B. separatus Dalla Torre, 1896, p. 546 (part).

B. ridingsii Britton and Viereck, 1906, pp. 216, 217, 220. CONNECTICUT; at *Prunus persica*, *Pyrus malus*, and *Rubus nigrobaccus* and *strigosus*.

B. ridingsii Swenk, 1907, p. 296. South Bend and Omaha, NEBRASKA; V; at *Rubus occidentalis*. "We have never taken workers or males" in Nebraska.

Lovell, 1907, p. 199. Waldoboro, MAINE; at *Rhodora canadensis* and *Diervilla trifida*.

Smith, 1910, p. 698. Philadelphia, PENNSYLVANIA.

Franklin, 1913, p. 305. "Very rare in southeastern CANADA, ranging southward through New England and Middle Atlantic States into GEORGIA and ALABAMA" and LOUISIANA.

Viereck, 1916, p. 758. New Haven, Branford, and Southington, CONNECTICUT; V-VII.

Bequaert, 1920, p. 9. Forest Hills, Cohasset, and Sherborn, MASSACHUSETTS.

[P.] *bolsteri* Franklin, 1913, p. 357. ♀, ♂. Bay of Islands, Little River, and Humber River near Deer Lake, NEWFOUNDLAND.

Lutz, 1916, p. 515. ♂. Spruce Brook (Leng) and Codroy (Gratacap), NEWFOUNDLAND.

[B.] *borealis* Kirby, 1837. ♀. Lat. 65°, North America.

Cresson, 1864, p. 41. ♀, ♂, ♂. CANADA; (Saunders). NEW YORK; (Ashton).

B. fervidus Putnam, 1864, p. 99. Bridport, VERMONT. Warwick, MASSACHUSETTS. Nest.

Cresson, 1879, p. 230. NEW HAMPSHIRE. WEST VIRGINIA.

B. fervidus Radoszkowski, 1884a, p. 77. Based one of his groups on this species.

Provancher, 1888, p. 340. Ottawa and Cap Rouge, CANADA.

Coville, 1890, pp. 198. 201. Ithaca, NEW YORK. Habits.

Evars, 1896, p. 13. Sudbury, ONTARIO.

Lovell, 1898a, p. 387. At *Cornus stolonifera*.

Lovell, 1907, p. 198. Waldoboro, MAINE; VIII-IX; at *Pontederia cordata*, *Vicia cracca*, and *Trifolium pratense*.

Fletcher and Gibson, 1908, p. 111. Beaver Lake, ALBERTA; (Halkett).

Smith, 1910, p. 698. NEW JERSEY.

Greenicher, 1911, p. 249. Gordon in Douglas County, Swiss and the mouths of the Nemakagon and Yellow Rivers in Brunett Counties, Divide in Vilas County, and Jacksonport in Door County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 282. NEWFOUNDLAND. NEW BRUNSWICK. QUEBEC. Nepigon and Lake of Bays, ONTARIO. MANITOBA. Amherst, MASSACHUSETTS. MICHIGAN. St. Paul and Lake Itasca, MINNESOTA. "In western Canada its range seems to end on the eastern side of the Rocky Mountains where it is completely replaced by its close ally, *B. appositus*."

Franklin 1915, p. 414. Fargo, NORTH DAKOTA. Detroit and Moorhead, MINNESOTA; (Stevens).

Lutz, 1916, p. 520. Boisdale and Cape Breton Island (Leng) and Codroy (Gratacap), NEWFOUNDLAND. Campo Bello Island, NEW BRUNSWICK.

Sladen, 1919, p. 126. Related, through *appositus*, with the Eurasian *distinguendus*.

See *appositus*.

brachycephalus. See *diligens*.

cajennensis and *cayennensis*. See *incarum*, *medius*, and *mexicanus*.

[D.] *californicus* Smith, 1854, p. 400. ♀ (not the ♂). CALIFORNIA.

Cresson, 1863, p. 97. ♀ only.

B. dubius Cresson, 1863, p. 97. ♂ (the "?" removed in Cresson, 1916, p. 117). Western KANSAS; (Norton).

Cresson, 1875, p. 728. Eastern NEVADA; (Yarrow).

Apathus? californicus Cresson, 1879, p. 214. ♂. CALIFORNIA; (Edwards).

Cresson, 1879, p. 230. NEVADA. OREGON.

B. dubius Cresson, 1879, p. 230. COLORADO.

B. consanguineus Handlirsch, 1888, p. 239. ♀, ♂, ♂. Vancouver Island and mainland, BRITISH COLUMBIA.

Fox, 1893, p. 23. El Rosario, Lower California. MEXICO; V; (Haines). See Cockerell, 1899b, p. 19.

B. dubius Cockerell, 1893, p. 338. Near Swift Creek, Custer County, COLORADO.

Fowler, 1902, p. 317. Berkeley, Redoulo, and San Diego, CALIFORNIA; II-XI.

B. dibius Titus, 1902, p. 40. Fort Collins and Westlake, 8000 ft., COLORADO. VII.

B. neglectulus Ashmead, 1902, p. 124. ♀, ♂. ALASKA.

Cockerell, 1903, p. 452. Alum Rock Park, CALIFORNIA; (Ehrhorn).

Viereck *et al*, 1904, p. 99. Corvallis and Mt. Hood, OREGON. WASHINGTON. V, VI, IX-XI.

Cockerell, 1904e, p. 89. Los Angeles and Catalina Island, CALIFORNIA.

Psithyrus californicus Cockerell, 1904e, p. 90. Switzers, CALIFORNIA.

B. dubius Cockerell, 1906d, p. 453. Florissant, COLORADO; VII; at *Iris missouriensis* and white *Carduus*.

Fletcher and Gibson, 1907, p. 128. Prince Albert, and Calgary, ALBERTA; VII.

Fletcher and Gibson, 1908, p. 111. Olds, ALBERTA, (Willing); and Duncans, (Fletcher). If this Duncans is the one in Ontario the record seems doubtful.

Tucker, 1909, p. 277. Tabernash, COLORADO; VIII.

Davidson, 1911, p. 66. San Bernardino Mountains up to 6000 ft., CALIFORNIA.

Franklin, 1913, p. 393. "All the Pacific states and territories, except Montana and Arizona" (See below). Magdalena Mountains, NEW MEXICO.

Franklin, 1915, p. 414. Beaver Creek, MONTANA; 6300 ft.; (Hunter).

See *vosnesenskii*.

carriei. See *frigidus*.

castoris. See *rufocinctus*.

[P.] *centralis* Cresson, 1864, p. 41. ♀. Fort Crook, CALIFORNIA; (Ulke). 1879, p. 231; COLORADO.

B. justus Cresson, 1878a, p. 187. COLORADO; (Morrison). 1879, p. 231: NEVADA.

B. flavifrons Handlirsch, 1888, p. 231 (part).

B. justus Cockerell, 1898d, p. 71. Santa Fé Canyon, Ruidoso Creek, NEW MEXICO.

B. monardæ Cockerell and Porter, 1899, p. 387. Monument Rock, Santa Fé Canyon* (8000 ft.) and Rio Ruidoso (White Mountains, 6500-6600 ft.), NEW MEXICO; VII, VIII; at *Monarda stricta*, *Pontentilla thurbeori*, and *Allium cernuum*; (Cockerell, Townsend).

B. justus Cockerell, 1898d, p. 71, and Cockerell and Porter, 1899, p. 390. NEW MEXICO: Beulah; Harvey's Ranch, 9600 ft.; South Fork, Eagle Creek, White Mountains, 8000-8900 ft.; Rio Ruidoso, 6500-8300 ft.; east of Santa Fé, 7400 ft.; Santa Fé Canyon, 7600 ft.; V-VIII; at *Iris missouriensis*, *Sicyos parviflorus*, *Brittonastrum pallidum*, *Verbascum thapsus*, *Prunella vulgaris*, *Vicia*, *Monarda stricta*, *Mentzelia rusbyi*, *Solidago trinervata*, *Verbena stricta*, *Allium cernuum*, *Geranium richardsoni*, *Senecio*, *Cnicus* and *Rudbeckia*; (Porter, Cockerell, Townsend, Wooton).

B. justus Titus, 1902, p. 43. Livermore, Fort Collins, Virginia Dale, Estes Park (Gillette), North Park (Ball), and Palmer Lake, COLORADO; VII, VIII. The record from Woods Hole, Massachusetts, is certainly either a mistake or an accident. (See *affinis novæ-angliæ*.)

Cockerell, 1904, p. 234. Manitou, COLORADO; IV; at *Ribes leptanthum*.

Cockerell, 1906, p. 313. Cloudercroft, NEW MEXICO. "Canadian Zone."

B. justus Cockerell, 1906d, p. 453. Florissant, and Four Mile on the Cripple Creek road (Bentley), COLORADO; VI, VII.

B. justus Swenk, 1907, p. 297. "Pine Ridge Country," Sioux County, NEBRASKA; V-LX.

B. justus Cockerell, 1907b, p. 257. Boulder, COLORADO.

(?) *B. praticolus* Fletcher and Gibson, 1908, p. 111 (part).

Cockerell, 1910d, p. 128. Meeker, New Castle, and Rifle Gap, COLORADO; at *Cleome serrulata*; (Robbins). *Centralis* considered a valid race of *justus*.

B. justus Davidson, 1911, p. 66. Seven Oaks and Bear Valley, San Bernardino Mountains, CALIFORNIA.

Franklin, 1913, p. 371. BRITISH COLUMBIA. WASHINGTON. IDAHO. WESTERN MONTANA. OREGON. WYOMING. NEVADA. UTAH. ARIZONA.

B. justus Cockerell, 1919c, p. 272, Gold Hill, COLORADO; 8600 ft.; VII; at *Fraseria*.

cevallia. See *americanorum*.

[P.] **cockerelli** Franklin, 1913, p. 356. ♀, ♂. New name for *B. prunellæ* Cockerell and Porter, 1899, p. 391, in part. Rio Ruidoso, White Mountains, NEW MEXICO; 6500-8200 ft.; VII, VIII; at *Monarda stricta*, *Verbena stricta*, *Solidago trinervata*, *Prunella vulgaris*, *Potentilla thurberi*, *Rhus glabra*, *Sicyos parviflorus*, *Geranium atropurpureum*, *Vicia* near *pulchella*, *Commelina dianthifolia*, and *Mentzelia rushyi*. Franklin states that Cloudercroft, NEW MEXICO, is the only other known locality and gives synonymy which questionably involves *B. consimilis* of Viereck, 1902, p. 44 (Beulah, NEW MEXICO; VI) and of Cockerell, 1906, p. 313.

B. prunellæ Cockerell, 1901c, p. 38. At *Commelina dianthifolia*.

coloradensis. See *occidentalis*.

columbicus. See *vosnesenskii*.

consanguineus. See *californicus*.

consimilis. See *cockerelli* and *vagans*.

cooleyi. See *edwardsii*.

[P.] **couperi** Cresson, 1878a, p. 185. ♀. CANADA; (Couper).

Fletcher and Gibson, 1908, p. 111. Nepigon, ONTARIO; (Fletcher). ANTI-COSTI ISLAND, Canada; (Schmitt).

Franklin, 1913, p. 360. LABRADOR. Mountains east of Codroy and Bay of Islands, NEWFOUNDLAND. Isle Royale, MICHIGAN.

Bremus couperi Frison, 1919, p. 451. ♀, ♂. Painsec, NEW BRUNSWICK; (Sladen).

See *frigidus*.

cressoni. See *nevadensis*.

[F.] **crotchii** Cresson, 1878a, p. 184. ♀. CALIFORNIA; (Crotch).

B. nigrocinctus Provancher, 1888, p. 342.

Fowler, 1902, p. 317. Tulare and Ventura, CALIFORNIA; V, VI.

B. (Bombias) crotchii Franklin, 1913, p. 434. Los Angeles County, San Bernardino County, San José, Ontario, Claremont, and San Diego, CALIFORNIA.

derhamellus. See *frigidus* and *sitkensis*.

[F.] **diligens** Smith, 1861, p. 154. Oaxaca, Mexico.

B. brachycephalus Handlirsch, 1888, p. 244. ♀, ♂, ♂. Orizaba, MEXICO; (Bilimek).

Fox, 1895, p. 272. Tepic, MEXICO.

B. (Bombias) brachycephalus Franklin, 1913a, p. 143.

Franklin, 1915, p. 411. Omilteme, Guerrero, MEXICO; 8000 ft. El Jicaró, Vera Paz, and San Geronimo, GUATEMALA; (Champion).

dimidiatus. See *flavifrons*.

[D.] **dolichocephalus** Handlirsch, 1888, p. 244. ♀, ♂. Orizaba, MEXICO; (Bilimek).

Franklin, 1913a, p. 108. ♂. Orizaba, MEXICO. Olas de Moka, Solola, GUATEMALA; 3000 ft.

Franklin, 1915, p. 415. MEXICO: Amula (6000 ft.), Xycumanatlan (7000 ft.), and Acaguitzotla (3500 ft.)—all in Guerrero—; Tepic and Jalisco. (Schumann).

dorsalis. See *fervidus dorsalis*.

dubius. See *californicus*.

[P.] **edwardsii** Cresson, 1878a, p. 184. ♀, ♂*, (not ♂). CALIFORNIA.* Vancouver Island, BRITISH COLUMBIA; (Edwards). COLORADO; (Morrison). Possibly one of the last two is erroneous.

(?) *B. ternarius* Putnam, 1876, p. 189, and Cresson, 1876, p. 210. Fort Bridger, WYOMING. Empire, COLORADO.

B. bifarius Cresson, 1878a, p. 185. ♀*, ♂. COLORADO.* Vancouver Island, BRITISH COLUMBIA.

B. vancouverensis Cresson, 1878a, p. 187. ♂ (in part). Vancouver Island, BRITISH COLUMBIA; (Edwards).

B. ternarius lacustris Handlirsch, 1888, p. 230.

B. nearcticus Handlirsch, 1888, p. 243. ♀, ♂, ♂. BRITISH COLUMBIA.

(?) *B. ternarius* Cockerell and Porter, 1899, p. 390. Rio Ruidoso (6700–8200 ft.), Beulah, Harvey's Ranch (9600 ft.), Aztec, and Mescalero, NEW MEXICO; V, VII, VIII; at *Rudbeckia laciniata*, *Verbascum thapsus*, *Mentzelia rusbyi*, *Monarda stricta*, *Vicia* near *pulchella*, *Solidago trinervata*, *Iris missouriensis*, and wild plum; (Townsend, Porter, Nead, and Otis). This reference may belong to *huntii*.

B. bifarius Titus, 1902, p. 43. Fort Collins, Boulder, Westlake, Rist Canyon, Marshall Pass, Alder, Lamar, Cimmaron, Ward, Muldoon, Palmer

Lake, Ridgeway, and Steamboat Springs, COLORADO; V-VIII; (Bruneo, Gillette, and Ball).

B. "nearcticus" Ashmead, 1902a, p. 127. Juneau, VII, and Wrangell (Wickham), ALASKA.

B. ternarius bifarius Viereck, 1902, p. 44. Beulah, NEW MEXICO; VI; at *Jamesia americana*.

B. cooleyi Morrill, 1903, p. 222. ♀. Bridger Mountain (6000 ft.), Bozeman (4800 ft.), Middle Creek Canyon, and Bridgen [Bridger ?] Canyon, MONTANA; VI, VII; (Cooley).

B. bifarius Viereck *et al.*, 1904, p. 99. WASHINGTON.

(?) Viereck *et al.*, 1904, p. 100. Fort McLeod, CANADA; VIII.

Cockerell, 1906, p. 313. Pecos, NEW MEXICO; VI; at *Fallugia*; (W. P. Cockerell).

Cockerell, 1906a, p. 74. Ward, COLORADO; 9000 ft.; at *Phacelia*.

Cockerell, 1907c, p. 97. CALIFORNIA. NEVADA.

Fletcher and Gibson, 1908, p. 111. Mt. Arrowsmith and Duncans, BRITISH COLUMBIA; (Fletcher). Banff, ALBERTA; (Sanson).

B. edwardsii cooleyi and *B. bifarius* Cockerell, 1910a, p. 25. Calgary, ALBERTA; (Dod).

(?) Davidson, 1911, p. 66. Sequoia National Park, San Bernardino Mountains, and San Fernando, CALIFORNIA. Nest. These may be *fernaldi*, according to Franklin, 1913, p. 329.

Franklin, 1913, p. 328. IDAHO. UTAH.

Bombus edwardsii kenoyeri and *B. e. bifarius* Cockerell, 1915b, p. 483. ♀. Tolland, COLORADO; at *Frasera stenosepala*; (Kenoyer).

B. edwardsii bifarius Cockerell, 1919b, p. 294. Timber line on Longs Peak trail, COLORADO; at *Elephantella*; (W. P. Cockerell).

See *fernaldi* and *rufocinctus*. Probably the varieties, especially *bifarius*, should be distinctly recognized.

elatus. See *americanorum*, *fervidus*, and *perplexus*.

[P.] *ephippiatus* Say, 1837, p. 414. MEXICO.

B. lateralis Smith, 1879, p. 134. ♂. Val de Fuego, GUATEMALA. Irazu, COSTA RICA; 6000-7000 ft.

B. ephippiatus lateralis Handlirsch, 1888, p. 233.

B. schneideri and var. *fuliginosus* Friese, 1903, p. 253. San Carlos, COSTA RICA. Chiriqui, PANAMA.

B. ephippiatus lateralis Crawford, 1906, p. 157. ♀, ♂. Cartago (4950 ft.), San José (3550 ft.), and (Bruner) Volcano Irazu (6000-9000 ft.), COSTA RICA; VI; at *Dahlia*. What appears to be the last paragraph of Crawford's remarks on this species refers to *volucelloides*, the name having been omitted in printing.

Franklin, 1913a, p. 86. San Carlos, La Estrella de Cartago, and Zarsero, COSTA RICA. ECUADOR.

Franklin, 1915, p. 414. Purula, GUATEMALA. Volcan de Chiriqui, PANAMA; 2000-3000 ft.; (Champion). Rio Sarstoon, BRITISH HONDURAS.

B. schneideri Friese, 1916, p. 298. San Mateo, (*B. schneideri badiocollis* Friese) San Carlos, and (*B. ephippiatus lateralis* Smith, p. 299) San Carlos. all COSTA RICA.

See *nigrodorsalis*, *pulcher*, and *wilmatta*.

ephippiatus pulcher. See *formosus*.

expallidus. See *ternarius expallidus*.

[P.] **fernaldi** Franklin, 1911, p. 157. ♀, ♂, ♂. Santa Clara County, Lake County, Nevada County, San José County, Mendocino, Sonoma County, Palo Alto, and Yosemite, CALIFORNIA. NEVADA. And, *B. edwardsii* Fowler, 1902, p. 317: Berkeley and San Francisco, CALIFORNIA; II-X. Franklin designated Fowler's specimens as the types of *fernaldi* but asks if "those specimens [can] be identified with certainty." Fowler's description, in his table, clearly indicates *fernaldi* rather than *edwardsii* as these are defined by Franklin.

ferrugineus. See *terrestris moderatus*.

[D.] **fervidus** Fabricius, 1798, p. 274. (*Apis*) North America.

Fabricius, 1804, p. 352.

Harris, 1835, p. 70. MASSACHUSETTS.

Lepelletier, 1837, p. 470. ♀. Philadelphia, PENNSYLVANIA.

Cresson, 1863, p. 93. ♀, ♂, ♂. CANADA. CONNECTICUT. NEW YORK.

DELAWARE. VIRGINIA. KANSAS. UTAH.

Putnam, 1864, p. 98 (part). Warwick, MASSACHUSETTS.

Riley, 1870, p. 303. Le Roy, NEW YORK.

Cresson, 1875, p. 728. Eastern NEVADA; (Yarrow).

Putnam, 1876, p. 189, and Cresson, 1876, p. 210. Fort Bridger, WYOMING.

Davenport, IOWA. Spring Lake, UTAH.

Cresson, 1879, p. 230. CALIFORNIA.

Bowles, 1880, p. 33. Quebec and Montreal, CANADA.

Provancher, 1883, p. 735. Have not seen.

Coville, 1890, p. 201. Ithaca, NEW YORK. Discussed the "*Apathus elatus*" error. See also Robertson, 1890, p. 41.

Evans, 1896, p. 13. Sudbury, ONTARIO.

Cockerell and Porter, 1899, p. 387. Las Vegas and Rio Ruidoso at about 6700 ft. in White Mountains, NEW MEXICO; VII, VIII; at *Petalostemon candidus* and *Vicia*.

Cockerell, 1899, p. 157. Pasco, WASHINGTON; V; (Kincaid).

Cockerell, 1901c, p. 42. At *Petalostemon candidus*.

Tirus, 1902, p. 40. Fort Collins, Livermore, Antonito, Trinidad, Montrose, Fort Lupton, and Boulder, COLORADO; V-IX; (Gillette and Haynes).

(?) Fowler, 1902, p. 317. San Diego and Berkeley, CALIFORNIA; V, X.

Meehan, 1902, p. 35. At *Lobelia syphilitica*.

(?) Viereck, 1902, p. 44. Beulah, NEW MEXICO.

B. pennsylvanicus Robertson, 1903, p. 177.

B. pennsylvanicus Viereck *et al.*, 1904, p. 98. Condon, OREGON; VII, IX; (Cordley).

Jarvis, 1905, p. 128. Ottawa, CANADA.

Lovell, 1907, p. 197. Waldoboro, MAINE; V-IX; at *Rhodora canadensis*, *Æsculus hippocastanum*, *Falcata comosa*, *Trifolium pratense*, and *Pontederia cordata*.

B. pennsylvanicus Swenk, 1907, p. 296. Sioux County, Lincoln, Omaha, Weeping Water, West Point, Neligh, Springview, and Gordon, NEBRASKA; V-IX; at *Astragalus*, *Rubus*, *Petalostemon*, *Monarda*, *Mentha*, *Carduus*, *Solidago*, and *Helianthus*.

Fletcher and Gibson, 1907, p. 128. McLeod, ALBERTA; VI; (Fletcher).

B. pennsylvanicus Grænicher, 1907, p. 26. ♀, ♂. WISCONSIN; at *Allium cernuum*.

Tucker, 1909, p. 277. Wichita, KANSAS; VIII. Colorado Springs and Denver, COLORADO; VIII.

Cockerell, 1910d, p. 128. Rifle Gap and Meeker, COLORADO; (Robbins).

B. ternarius Smith, 1910, p. 698. Staten Island, NEW YORK; (Davis).

Cockerell, 1911, p. 390. Woods Hole, MASSACHUSETTS; (Eleth Cattell).

Davidson, 1911, p. 66. Los Angeles, CALIFORNIA.

B. pennsylvanicus ("=*fervidus*") Grænicher, 1911, p. 249. Mouth of the Yellow River in Burnett County. Never's Dam in Polk County, and Maiden Rock in Pierce County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 388. Regina, ASSINIBOIA. "This species is present throughout all the states of the United States, except as follows: Florida, Louisiana, Alabama, Mississippi, the greater part of Texas, the eastern half of Oklahoma, the greater part of Arkansas, the greater part of Georgia, the eastern half of North and South Carolina, eastern Virginia and the western portions of Tennessee and Kentucky."

Crawford, 1913, p. 269. Red Head, St. John, and Nerepis, NEW BRUNSWICK; VII-IX.

Viereck, 1916, p. 757. New Haven, Brarford, East Hartford, Mt. Carmel, Salisbury, Torrington, and Milford, CONNECTICUT.

Cockerell, 1916c, p. 9. Whitefish Point, Chippewa County, MICHIGAN; VI; (Andrews).

Cockerell, 1917e, p. 212. Falls Church, VIRGINIA; at *Helianthus annuus zonatus*.

Bequaert, 1920, p. 9. Forest Hills, Auburndale, Cohasset, and Sherborn, MASSACHUSETTS.

See *americanorum* and *borealis*.

- [D.] ***fervidus dorsalis*** Cresson, 1879, p. 230. ♀. No locality given but Cresson, 1916, p. 117, says it is CANADA.

B. dorsalis Lovell, 1898a, p. 385. (?) Waldoboro, MAINE; at *Chelone glabra*.

B. nevadensis aztecus Cockerell, 1899a, p. 389. ♀. Aztec, Las Vegas, Beulah, Mescalero Agency, and Rio Ruidoso (6700-6900 ft.), NEW MEXICO; V-VIII; at *Verbena bipinnatifida*, *Monarda stricta*, *Lupinus silgreavesii*, and *Verbascum thapsus*; (Porter, Barber, and Townsend).

B. dorsalis Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VII, VIII; (Snow).

B. dorsalis Cockerell, 1906, p. 313. "Canadian to Upper Sonoran."

B. dorsalis Cockerell, 1906d, p. 453. Florissant, COLORADO; VII; at *Capnoides*; (Rohwer).

- [P.] ***flavifrons*** Cresson, 1863, p. 105. ♀, ♂, ♂*. Fort Yukon*, ALASKA. HUDSON BAY TERRITORY. Kansas. The latter is probably erroneous.

- (?) *B. praticola* Kirby, 1837, p. 274. ♀. Lat. 65°, North America.
 Putnam, 1876, p. 195, and Cresson, 1876, p. 210. Spring Lake, Utah
 County, UTAH. Empire, COLORADO. (Putnam)
 Bowles, 1880, p. 33. Montreal, CANADA.
 Handlirsch, 1891, p. 452 (part). BRITISH COLUMBIA.
 Viereck, 1901, p. 325. Eagle City, ALASKA; 65° 30' N.; (Kirk).
 Titus, 1902, p. 43. Marshall Pass, Lizard Head (Ball), and Ward,
 COLORADO; VIII.
B. alaskensis Ashmead, 1902a, p. 128. ♀, ♂. Sitka and Fox Point,
 ALASKA; VI, VII.
B. dimidiatus Ashmead, 1902a, p. 129. ♀, ♂. Fox Point and Wrangell
 (Wickham), ALASKA; VII.
B. flavifrons veganus Cockerell, 1903a, p. 891. ♂. Top of Las Vegas
 Range, NEW MEXICO; about 11,000 ft. Typical specimens of *flavifrons* there
 and above timber line on Truchas Peaks (W. P. Cockerell), also at Beulah
 (Skinner), NEW MEXICO. 1906, p. 312: "Arctic Alpine to Canadian."
 Cockerell, 1907b, p. 257. Eldora (Rohwer) and above timber line on Ara-
 pahoe Peak (W. P. Cockerell), COLORADO; VIII.
B. praticolus Fletcher and Gibson, 1908, p. 111. St. Albert, ALBERTA;
 (Fletcher). (?) Metlakatla, BRITISH COLUMBIA; (Keen).
 Tucker, 1909, p. 277. Cheyenne Canyon near Colorado City, Buffalo,
 and Colorado Springs, COLORADO; VII, VIII.
B. flavifrons dimidiatus Cockerell, 1910a, p. 25. Calgary, ALBERTA.
 Franklin, 1913, p. 368. Metlakatla, Fort Yukon, and Juneau, ALASKA.
 Vancouver, BRITISH COLUMBIA. Blue Mountains, WASHINGTON. IDAHO.
 MONTANA.
 Sladen, 1915, p. 84. Agassiz, BRITISH COLUMBIA; VII; (Treherne). Nest;
 see *Psithyrus insularis*.
 Cockerell, 1915b, p. 483. Nebraska Hill and Corona (above timber line),
 COLORADO; at *Trifolium dasycarpum* and *Mertensia bakeri*; (Kenoyer).
 Cockerell, 1919b, p. 294. Hudsonian zone on Longs Peak trail, COLORADO.
 See *centralis* and *vosnesenskii*. It seems that *dimidiatus*, at least, should
 be recognized as a variety.

[P.] **formosus** Smith, 1854, p. 403. ♀. Oaxaca, MEXICO, the published
 locality (India) being wrong; see Cockerell, 1899b, p. 19, and Meade-
 Waldo, 1916, p. 469.

- B. pulcher* Cresson, 1863, p. 108. ♀. Jalapa, MEXICO; (Akhurst).
B. ephippiatus pulcher Handlirsch, 1888, p. 233.
 Franklin, 1913a, p. 91. Ixtaceihautl, Popocatepetl (8000 ft.), and Ozumba
 [Orizaba?], MEXICO. Olas de Moka, Department Solola, GUATEMALA.
 VENEZUELA.
 Franklin, 1915, p. 414. MEXICO: Xucumanatlan, 7000 ft., (Smith), and
 Omilteme, 8000 ft., both in Guerrero; Cuidad, 8100 ft., (Forrer); and
 Orizaba. Santa Cruz, San Geronimo, and Capetillo, GUATEMALA;
 (Champion).

[F.] **fraternus** Smith, 1854, p. 385. (*Apathus*) ♂. North America.

B. scutellaris Cresson, 1863, p. 96. ♀*, ♀. TEXAS*. FLORIDA.

Apathus fraternus Cresson, 1863, p. 111. New Wied, TEXAS.

B. scutellaris Patton, 1879, p. 360. Northwestern KANSAS; IX; at *Solidago*; (Williston).

B. scutellaris Robertson, 1891a, pp. 571, 574, 577, 589, 597. Carlinville, ILLINOIS; at *Asclepias incarnata* and *sullivantii*, *Acerates longifolia*, *Collinsia verna*, and *Gerardia tenuifolia*.

B. scutellaris Robertson, 1894, pp. 452-475. Macoupin County, ILLINOIS; at *Eupatorium serotinum*, *Solidago canadensis* and *lanceolata*, *Helianthus grosseserratus*, *Coreopsis aristosa*, *Helenium autumnale*, and *Cnicus altissimus discolor*.

Psithyrus fraternus Dalla Torre, 1896, p. 569.

B. scutellaris Robertson, 1896, p. 159. At *Æsculus hippocastanum*.

B. scutellaris Robertson, 1898a, p. 244. At *Helianthus divaricatus*.

B. scutellaris Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

B. scutellaris var. Cockerell and Porter, 1899, p. 390. ♀. Las Vegas, NEW MEXICO; VIII; at *Petalostemon candidus*.

B. scutellaris Titus, 1902, p. 41. Fort Collins and (Ball) Julesburg, COLORADO; VII, VIII.

B. scutellaris Harris and Kuchs, 1902, p. 25. St. Joseph, MISSOURI; at *Solanum rostratum*.

B. scutellaris Viereck, 1903a, p. 132. Anglesea, NEW JERSEY; VIII; at *Asclepias pulchra*.

Bombias scutellaris Robertson, 1903, pp. 176, 177.

Bombias scutellaris Viereck, 1906, p. 224. Galveston, TEXAS; V; (Snow). Cockerell, 1906, p. 313. "Upper Sonoran."

B. scutellaris Dæcke, 1907, p. 265. Lucaston, NEW JERSEY; IX.

Bombias scutellaris Swenk, 1907, p. 294. Lincoln, Omaha, Nebraska City, West Point, Carns, and Sioux County, NEBRASKA; VI-X; at *Carduus*, *Helianthus*, *Solidago*, and *Grindelia*.

B. scutellaris Tucker, 1909, p. 278. Wichita, KANSAS; VIII.

Bombias scutellaris Smith, 1910, p. 699. Brown Mills, NEW JERSEY; VIII, IX.

B. (Bombias) fraternus Franklin, 1913, p. 421. LOUISIANA. MISSISSIPPI. ALABAMA. GEORGIA. NORTH and SOUTH CAROLINA. OKLAHOMA. ARKANSAS. TENNESSEE. MISSOURI. KENTUCKY. Eastern VIRGINIA. Eastern MARYLAND. DELAWARE. Lakehurst, NEW JERSEY. OHIO. INDIANA. ILLINOIS. IOWA. Hugo and Berkeley, COLORADO.

[P.] **frigidus** Smith, 1854, p. 399. ♀, ♂. HUDSON BAY. (See Meade-Waldo, 1916, p. 469.)

B. derhamellus Kirby, 1837, p. 273. Lat. 65°.

B. cariei Greene, 1860, p. 170. ♀. Fort Steilacoom, "Washington Territory"; (Suckley).

Cresson, 1863, p. 100 (not the ♂). Great Slave Lake and Yukon River, (Kennicott); and Puget Sound, (Norton).

Provancher, 1888, p. 341. Ottawa, CANADA; (Guignard).

Handlirsch, 1891, p. 454 (part). BRITISH COLUMBIA. Yale and Lytton, "Washington Territory."

(?) *B. derhamellus* Fox, 1892, p. 134. Herbert Island and McCormick Bay, West GREENLAND; VII.

Cockerell, 1901b, p. 361. Summit of the range between the Pecos and Sapello rivers, near the headwaters of the Pecos, NEW MEXICO.

B. couperi and (?) *B. oregonensis* Titus, 1902, p. 44. Ward and Lizard Head, COLORADO; VIII; (Ball).

B. couperi Ashmead, 1902a, p. 126. Popoff Island, Seldovia, and Nushagak River (McKay), ALASKA; VII. See *strenuus* for Ashmead's *frigidus*.

Cockerell, 1903a, p. 891. Truchas Peaks, NEW MEXICO; above timber line.

B. derhamellus silkenensis Friese, 1904b, p. 518. Makes *frigidus* a synonym.

(?) Cockerell, 1906, p. 312. Truchas Peak, above timber line (W. P. Cockerell) and top of Las Vegas Range, NEW MEXICO. "Arctic Alpine to Hudsonian."

Cockerell, 1907b, p. 257. Arapahoe Peak, above timber line, VIII, (W. P. Cockerell), and Eldora, IX, (Rohwer), COLORADO.

Franklin, 1913, p. 360. Eagle, ALASKA. Ft. Rae, MACKENSIE. Ungava Bay, LABRADOR. NEWFOUNDLAND. Fremont Pass, COLORADO; (11,500–12,000 ft).

Lutz, 1916, p. 516. Athabasca River, ALBERTA; (Anderson). Collins, IDAHO.

Sladen, 1919a, p. 31a, ♂, ♀. Nome, ALASKA; (Johansen).

See *miztus* and *strenuus*.

fuliginosus. See *ephippiatus*.

[F.] *funebria* Smith, 1854, p. 400. ♀. Quito, ECUADOR.

Cameron, 1903, p. 237. ♀, ♂. Machachi (9000–10,000 ft.), Hac. Guachala (9217 ft.), Pichincha (11,500 ft.), Chillo (9000 ft.), S. Lucia (8000 ft.) and Hac. S. Rosario (10,300 ft.), ECUADOR; (Whymper; see his 'Travels amongst the Great Andes of the Equator').

B. (Bombias) funebria Franklin, 1913a, p. 157. Tarata, BOLIVIA. Callanga, PERU. COLOMBIA. Atypical specimens, COSTA RICA.

Franklin, 1915, p. 415. Pachacayo, PERU; over 12,000 ft.; (Townsend).

[P.] *golidus* Cresson, 1878a, p. 184. ♀. ALEUTIAN ISLANDS; (Edwards).

Franklin, 1913, p. 341. Popoff Island, Koyuku River, Kukak Bay, and Nualaska, ALASKA. Signuia, BAFFIN LAND.

See *kincaidii*.

griseocollis. See *impatiens*.

grænlandicus. See *arcticus*.

guatemalensis. See *wilmattæ*.

[F.] *haueri* Handlirsch, 1888, p. 234. ♀. Orizaba and Tukubaya, MEXICO; (Bilimek).

Franklin, 1907, p. 91 and (*B. Bombias haueri*) Franklin, 1913a, p. 141, ♀, ♂. Mexico City, Es lava, and Meadow Valley (head of Rio Piedras Verdes, six miles south of Colonia Garcia in the Sierra Madre of western Chihuahua), MEXICO.

[F.] *henshawii* Franklin, 1913, p. 446. (*B. Bombias*) ♀. San Francisco and Palo Alto, CALIFORNIA.

hortorum. See *alboanalis*.

howardi. See *occidentalis*.

hudsonicus. See *perplexus*.

[P.] *huntii* Greene, 1860, p. 172. ♀. "Utah Territory."

B. ternarius Cresson, 1863, p. 104. ♀, ♀, ♂, (part). Probably the Utah and Puget Sound records.

B. ternarius Cresson, 1875, p. 728. COLORADO; (Rothrock). NEW MEXICO; (Loew).

B. ternarius Putnam, 1876, p. 189. Fort Bridger, WYOMING.

B. ternarius Cresson, 1876, p. 210. Empire, COLORADO.

Cockerell, 1893, p. 337. Willow Creek, Cusack Ranch, and also at timber line, Custer County, COLORADO; VIII.

(?) *B. ternarius* Cockerell and Porter, 1899, p. 390. Rio Ruidoso (6700-8200 ft.), Beulah, Harvey's Ranch (9600 ft.), Aztec, and Mescalero, NEW MEXICO; V, VII, VIII; (Townsend, Porter, Mead, and Otis). May be *edwardsii*, under which we have given the flower records.

B. ternarius Cockerell, 1899, p. 156. Seattle, WASHINGTON; III; (Kincaid).

B. ternarius Titus, 1902, p. 42. Fort Collins, Bellvue, Livermore, Ridgeway, Lamar, Virginia Dale, Westlake, Durango, Antonito, Clear Creek Canyon, Ward, Glenwood Springs, and Salida, COLORADO; III-IX.

B. ternarius Viereck *et al.*, 1904, p. 99. Condon and Corvallis, OREGON; VII, VIII; (Tulley).

(?) *B. ternarius* Viereck, 1906, p. 245. Near Lander, WYOMING.

B. rufosuffusus Cockerell, 1905a, p. 271. ♀. Boulder, COLORADO; VI; (W. P. Cockerell). May be distinct.

Cockerell, 1906, p. 312. Truchas Peak, above timber line (W. P. Cockerell), and top of Las Vegas Range, NEW MEXICO. "Arctic Alpine to Transition."

Cockerell, 1906d, p. 453. Florissant and (*rufosuffusus*) Topaz Butte, COLORADO; VI; at *Ribes longiflorum*, *Polemonium*, *Pentstemon secundiflorus* and *Pedicularis*; (Rohwer, Wheeler and Cockerell).

Swenk, 1907, p. 297. "Pine Ridge country," Sioux County, NEBRASKA; V-IX; at *Astragalus*, *Symphoricarpos*, *Campanula*, *Borago*, *Melilotus*, *Monarda*, *Cleome*, *Carduus*, and *Helianthus*.

Fletcher and Gibson, 1907, p. 128. McLeod, ALBERTA; VI; (Fletcher).

Cockerell, 1910d, p. 128. New Castle, Meeker, and near Axial, COLORADO; at *Cleome*, *Solidago* and *Rudbeckia*; (Robbins).

Crawford, 1912, p. 359. Medicine Hat, ALBERTA; (Malloch).

Franklin, 1913, p. 319. CALIFORNIA (except probably the Lower Austral portion). NEVADA. Western SOUTH DAKOTA. Vancouver Island and Fort McLeod, BRITISH COLUMBIA. Regina in the old territory of ASSINIBOIA.

Franklin, 1915, p. 414. Sentinel Buttes, NORTH DAKOTA; (Stevens).
Cockerell, 1915d, p. 331. Boulder, COLORADO; pollinating *Cattleya mossia* in a greenhouse.

See *laticinctus* and *ternarius*.

hyperboreus. See *arcticus*.

hyperboreus albertensis. See *rufocinctus*.

[P.] **impatiens** Cresson, 1863, p. 90. ♂. CANADA. CONNECTICUT. PENNSYLVANIA. ILLINOIS. MISSOURI. Description of *B. impatiens* (nom.nud.) Harris, 1835, p. 70.

(?) *Apis griseo-collis* De Geer, 1773, p. 576.

Apis virginicus Olivier, 1789, p. 66, and *griseo-collis*, p. 64.

B. virginicus Fabricius, 1804, p. 346. VIRGINIA. Homonym.

Bremus virginicus Jurine, 1807, p. 260.

B. virginicus Smith, 1854, p. 398. St. John's Bluff, East FLORIDA.

B. virginicus Cresson, 1863, p. 87. ♀, ♂, not ♂. NEW YORK. DELAWARE. DISTRICT OF COLUMBIA. MISSISSIPPI. TEXAS. Discussion of synonymy. See also p. 90 (*impatiens*) and p. 166.

B. virginicus Putnam, 1864, p. 101. Bridport, VERMONT. Nest.

B. virginicus Cresson, 1876, p. 210. Davenport, IOWA.

B. virginicus Riley, 1880, p. 107. Marion, ALABAMA. Robbing honey bees.

B. virginicus Bowles, 1880, p. 33. Quebec and Montreal, CANADA.

B. virginicus Handlirsch, 1888, p. 228. NEVADA.

(?) *Psithyrus insularis* Provancher, 1888, p. 342. ♂ (not ♀).

B. virginicus Robertson, 1891a, pp. 569-597. At *Asclepias verticillata* and *incarnata*, *Phlox divaricata*, *Hydrophyllum virginicum* and *appendiculatum*, *Solanum nigrum*, *Linaria vulgaris*, *Scrophularia nodosa marilandica*, *Seymeria macrophylla*, *Gerardia pedicularia*, *purpurea*, *tenuifolia*, and *auriculata*.

B. virginicus Howard, 1891, p. 431. Horse-chestnut nectar possibly had a toxic effect.

B. virginicus Robertson, 1894, pp. 436-475. Macoupin County, ILLINOIS; at *Prunus serotina*, *Rosa humilis*, *Pyrus coronaria*, *Crataegus coccinea* and *crusgalli*, *Eupatorium purpureum* and *serotinum*, *Lacinaria* ["*Liatris*"] *pycnostachya*, *Solidago canadensis*, *nemoralis*, and *lanceolata*, *Aster novae-angliae*, and *paniculatus*, *Helianthus grosseserratus*, *Coreopsis aristosa*, *Helenium autumnale*, and *Cnicus altissimus discolor* and *lanceolatus*.

B. virginicus Robertson, 1896, pp. 156, 160, 165, 175. Carlinville, ILLINOIS; at *Aesculus*, *Gymnocladus canadensis*, and *Aster ericoides villosus*.

B. virginicus Robertson, 1898a, p. 242. At *Lonicera sullivantii*.

B. virginicus Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

B. virginicus Harris and Kucks, 1902, p. 25. St. Joseph, MISSOURI; at *Solanum rostratum*.

Viereck, 1903a, p. 119. College Park and Chestertown, MARYLAND; VIII-X; (Vanatta).

B. morrisonii Howard, 1904, Pl. III, fig. 37.

(?) *B. virginicus* Viereck, 1906, p. 240. Magdalena Mountains, NEW MEXICO; VII; (Snow).

B. virginicus Britton and Viereck, 1906, pp. 216, 217, 219. CONNECTICUT; at *Prunus avium* and *persica*, *Pyrus malus*, and *Cydonia vulgaris*.

B. virginicus Swenk, 1907, p. 296. Lincoln, Omaha, South Bend, Cedar Bluffs, Weeping Water, Meadow, Nebraska City, Falls City, and Nemaha City, NEBRASKA; IV; at *Prunus*, *Ribes*, *Rubus*, *Cassia*, and *Petalostemon*.

Fletcher and Gibson, 1907, p. 128. Ottawa, CANADA; X; (Fletcher).

B. virginicus Grænicher, 1907, pp. 26, 32, 40, 93. ♂, ♀. WISCONSIN; at *Allium cernuum*, *Clintonia borealis*, *Salmonia biflora*, and *Ribes cynosbati*.

B. virginicus Tucker, 1909, p. 278. Lawrence, KANSAS; VII-X.

Smith, 1910, p. 698. Throughout NEW JERSEY.

Grænicher, 1911, p. 249. Hudson in St. Croix County, Prescott and Maiden Rock in Pierce County, and Fountain City in Buffalo County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 309. "Most western records are Logansport, LOUISIANA, and Lincoln, NEBRASKA."

Franklin, 1915, p. 414. Lake Park, MINNESOTA; (Stevens).

Viereck, 1916, p. 758. Branford, New Haven Putnam, and Salisbury, CONNECTICUT.

Bequaert, 1920, p. 9. Forest Hills, Auburndale, Dedham, Brookline, Cohasset, and Sherborn, MASSACHUSETTS.

improbis. See *nevadensis*.

[D.] **incarum** Franklin, 1913a, p. 131. ♀, ♂, ♂. Callanga and Chanchamayo, PERU. Boquete, Chiriqui, PANAMA. Georgetown, BRITISH GUIANA. DUTCH GUIANA. Sapucay, PARAGUAY. Rio Grand do Sul, BRAZIL. This may be *Apis cajennensis* Fabricius, 1898, p. 273.

insularis. See *impatiens*.

interruptus. See *Psithyrus insularis*.

iridis. See *rufocinctus*.

juxtus. See *affinis novæ-angliæ*, *centralis* and *pleuralis*.

kenoyeri. See *edwardsii*.

[K.] **kincaidii** Cockerell, 1898, p. 324. ♀, ♂, ♂. St. Paul, PRIBILOF ISLAND, Bering Sea; VIII; at *Lathyrus*; (Kincaid).

(?) *B. gelidus* Ashmead, 1902a, p. 127. See Viereck, 1903a, p. 54.

Psithyrus kodiakensis Ashmead, 1902a, p. 130. ♂. Kodiak, ALASKA; VII. This synonymy is according to Franklin, who formerly (in litt.) considered *kodiakensis* to be *putnami* (*B. kirbyellus*). The latter determination would seem more probable, as *kincaidii* is not supposed to occur on the mainland. Ashmead says the pleura of his species is covered with ochreous hair, not dark as it should be in *kincaidii*.

[K.] **kirbyellus** Curtis, 1835, p. lxii. (*kirbiellus*) ♀, ♂, ♂. ARCTIC AMERICA.

(?) *B. balteatus* Dahlbom, 1832, p. 36.

(?) *B. tricolor* Dahlbom, 1832, p. 41.

For references to possible synonyms (*nivalis*, *balteatus*, *montanus*, and *nidulnas*) in the Palearctic region see Franklin, 1913, p. 290, and Dalla Torre, 1896, p. 527.

- B. kirbiellus* Smith, 1854, p. 397. Boothia Felix, Canada.
 MacLachlan, 1878, p. 106. Hayes Sound, lat. 79°, VIII; Fort Foulke, VII; and lat. 81° 45'; (Feilden).
B. putnami Cresson, 1878a, p. 185. ♀. COLORADO; (Putnam).
B. balleatus kirbiellus Aurivillius, 1890, p. 28. Polaris Bay, Ritenbenk, Godhavn, Auleitsivik, and Ivigtut, GREENLAND; (Kolthoff).
B. nidulans Handlirsch, 1891, p. 453. Lytton, BRITISH COLUMBIA.
 (?) *B. nivalis* Fox, 1892, p. 134. McCormick Bay, West GREENLAND; VII.
B. putnami Titus, 1902, p. 41. Fort Collins, Lizard Head, Ward, and Home, COLORADO; all, except Fort Collins, 7000 to 10,000 ft.; VIII; (Ball).
B. atrifasciatus Morrill, 1903, p. 224. ♀. Gallatin County, MONTANA; 9400 ft.; VII; (Cooley).
B. putnami Viereck *et al.*, 1904, p. 99. WASHINGTON. Mt. Hood, OREGON.
 Fletcher and Gibson, 1907, p. 129. Fullerton, Hudson Bay, and Mount Edith, Banff, CANADA; VII; (Halkett and Fletcher).
 Fletcher and Gibson, 1908, p. 111. Bartlett Bay, ALASKA; at sea-level; (Nelles).
 Franklin, 1913, p. 290. Truchas Peak, NEW MEXICO. LABRADOR. Sopka, SIBERIA.
 Cockerell, 1915b, p. 483. Nebraska Hill, COLORADO; above timber line; VII; at *Polemonium confertum* and *Trifolium*; (Kenoyer).
 Lutz, 1916, p. 520. Kodiak, ALASKA.
 Sladen, 1919a, p. 27g. ♂, ♀. Nome, Collinson Point, ALASKA, and Young Point, NORTHWEST TERRITORIES, (Johansen); Nottingham Island (McKenzie), Cape Chudleigh, Hudson Strait; Laggan (Fletcher), and Banff (Sanson), ALBERTA.
 See *kincaidii* and *pleuralis*.

kirbyellus pyropygus. Friese's remarks in 1902a and 1908a as to synonymy are somewhat confusing. See also 1912b, p. 182. He probably had no American specimens of *pyropygus*.

kodiakensis. See *kincaidii*.

laboriosus. See *nigrodorsalis* and *Psithyrus laboriosus*.

lacustris. See *edwardsii*, *melanopygus*.

lapponicus. See *sylvicola*.

lapponicus flavicollis. See *sylvicola flavicollis*.

lateralis. See *ephippiatus* and *wilmattæ*.

[P.] *laticinctus* Franklin, 1913a, p. 85. ♀. ♂*. Meadow Valley (head of Rio Piedras Verdes, six miles south of Colonia Garcia, Sierra Madre of western Chihuahua), MEXICO; 7000 ft.; (Townsend).
 May be a subspecies of *huntii*.

laticollis. See *nigrodorsalis*.

leucomelas. See *volucelloides*.

marylandicus. See p. (503).

mckayi. See *occidentalis*.

- [D.] *medius* Cresson, 1863, p. 97. ♀ (?). The locality (Utah) "no doubt an error for MEXICO" (Cresson, 1916, p. 123).

Apis cajennensis Fabricius, 1798, p. 273, may be the same. The various references to this are omitted.

(?) *B. unifasciatus* Smith, 1879, p. 133. GUATEMALA; 5000 ft. Irazu, COSTA RICA; 6000-7000 ft. "San Francisco"; 4500 ft.

Cockerell, 1905g, p. 90. San Rafael on the Rio Nautla, Vera Cruz, MEXICO; III, IV.

(?) *B. unifasciatus* Cockerell, 1912, p. 106. Guatemala City, GUATEMALA; XII; (Wheeler).

Franklin, 1913a, p. 123. ♀, ♂, ♂. Orizaba, Otoyac, and Coatepec, MEXICO. Olas de Moka, Solola, GUATEMALA. Boquete, Chiriqui, PANAMA. ECUADOR. Minas Geraes and São Paulo, BRAZIL. Sapucay (?), PARAGUAY.

(?) *B. unifasciatus* Cockerell, 1913a, p. 192. Guatemala City, Amatitlan. and Antigua, GUATEMALA; (W. P. Cockerell).

Franklin, 1915, p. 415. Valladolid, Yucatan, (Gauger), and Jalapa and Teapa, Tabasco, (Smith), MEXICO. San Geronimo, GUATEMALA. Bugaba, PANAMA; 800-1500 ft.; (Champion). Pará, BRAZIL; (Austen).

See *mexicanus*.

- [P.] *melanopygus* Nylander, 1848, p. 236. (*melanopyge*) ♂. Sitka.

(?) *B. ornatus* Smith, 1854, p. 398. ♀, ♂, ♂. HUDSON BAY.

(?) *B. menestriesii* Radoszkowski, 1859, p. 483.

B. lacustris Cresson, 1863, p. 103. ♀*, ♂, ♂. Lake Athabasca* and Great Slave Lake, CANADA; (Kennicott).

B. lacustris Cresson, 1879, p. 231. Vancouver, BRITISH COLUMBIA, and GREENLAND.

Handlirsch, 1888, p. 231. ALEUTIAN ISLANDS. Misspelled *melampygus*.

B. lacustris Provancher, 1888, p. 340. This Quebec record is probably erroneous.

B. sylvicola Cockerell, 1893, p. 337. Ula and Willow Creek, Custer County, COLORADO; VII, VIII.

B. ternarius lacustris Dalla Torre, 1896, p. 533, (part).

Ashmead, 1902a, p. 128. Berg Bay, Juneau, Kodiak, Seldovia, Wrangell, Seward Peninsula, and Sitka, ALASKA. Vancouver Island, BRITISH COLUMBIA; VI, VII. (Wickham, Peters, Fur Seal Commission).

(?) *B. sylvicola* Titus, 1902, p. 43. Lizard Head, Alder, Muldoon, Marshall Pass, and Ward, COLORADO; VIII; (Ball, Gillette, and Cockerell).

Viereck *et al.*, 1904, p. 99. Corvallis (Cordley) and Mt. Hood, OREGON; V.

Fletcher and Gibson, 1907, p. 129. Mount Edith, Banff, ALBERTA; VII; (Fletcher).

Franklin, 1913, p. 334. MACKENZIE. Fullerton, HUDSON BAY country. BAFFIN LAND. BRITISH COLUMBIA. SASKATCHEWAN. WASHINGTON. WYOMING.

Lutz, 1916, p. 515. Colorado Springs, COLORADO; above 6000 ft.; (Wickham).

Sladen, 1919, p. 127. "Probably a variety" of *sylvicola*.

menestriesii. See *melanopygus*.

[D.] **mexicanus** Cresson, 1878a, p. 187. ♀*, ♂. MEXICO; (Sumichrast).

(?) *B. unifasciatus* Smith, 1879, p. 133. GUATEMALA; 5000 ft. Irazu, COSTA RICA; 6000-7000 ft. "San Francisco"; 4500 ft. See *medius*.

(?) *B. cayennensis mexicanus* Handlirsch, 1888, p. 241. Yapanema, BRAZIL. GUATEMALA.

(?) *B. unifasciatus* Cockerell, 1912, p. 106. Guatemala City, GUATEMALA; XII; (Wheeler).

Franklin, 1913a, p. 128. ♀, ♂, ♂. Olas de Moka, Solola, GUATEMALA. San José, COSTA RICA. Boquete and Bogona, Chiriqui, PANAMA. ECUADOR.

Franklin, 1915, p. 415. Guatemala City, GUATEMALA; (W. P. Cockerell).

B. cayennensis mexicanus Friese, 1916, p. 298. San José, COSTA RICA; (Schmidt and Baydorf).

See *medius*.

[F.] **mexicensis** Franklin, 1911, p. 163. (*B. Bombias*) New name for *B. ternarius* d Handlirsch, 1888, p. 230: ♀; Takubaya, MEXICO; (Bilimek).

mixtuosus. See *silkensis*.

[P.] **mixtus** Cresson, 1878a, p. 186. ♀*, ♂. COLORADO; (Morrison).

B. frigidus Handlirsch, 1891, p. 454 (part).

Cockerell, 1893, p. 338. Near Swift Creek, Custer County, COLORADO.

Titus, 1902, p. 44. Fort Collins, Cameron Pass, Home, and Ward, COLORADO; V, VII.

B. oregonensis Ashmead, 1902a, p. 126. Fox Point, Kodiak, Juneau, Seldovia, and Popoff Island, ALASKA; VI, VII.

Fletcher and Gibson, 1908, p. 111. Metalakatla (Keen) and Mt. Cheam (Fletcher), BRITISH COLUMBIA. Banff, ALBERTA; (Sanson).

Franklin, 1913, p. 381. Vancouver Island, BRITISH COLUMBIA. LABRADOR. WASHINGTON. IDAHO. Bozeman, MONTANA. OREGON. Humboldt County, CALIFORNIA. WYOMING.

Cockerell, 1919b, p. 294. Battle Mountain, COLORADO; above timber line.

Sladen, 1919a, p. 31g. ♂. Poreupine Mountain district, YUKON TERRITORY; (Cairnes).

See *alboanalis*.

moderatus. See *terrestris moderatus*.

modestus. See *occidentalis*, *terrestris moderatus*, *trinominatus*.

monardæ. See *centralis*.

montanus. See *kirbyellus*.

montezumæ. See *nigrodorsalis*.

[F.] **mormonorum** Franklin, 1911, p. 161 (*B. Bombias*) ♀, ♂, ♂. Beaver Valley, Beaver Canyon, Beaver Creek, South Creek, Beaver County, UTAH.

[F.] **morrisoni** Cresson, 1878a, p. 183. ♀*, ♂, ♂. COLORADO; (Morrison).

Cresson, 1879, p. 230. NEW MEXICO. NEVADA.

Cockerell, 1898*d*, pp. 71, 73. Mesilla Valley, Organ Mountains, Lamy, Watrous, Albuquerque, and Sante Fé, New Mexico; IX; at *Cleome serrulata*. See also 1898*f*, p. 311.

Cockerell and Porter, 1899, p. 388. Las Vegas, Romeroville, Aztec, Ruidoso Creek at 6900-8200 ft., South Fork, Eagle Creek, Las Cruces, Mesilla Park, Dipping Spring in Organ Mountains, and Mescalero Agency, NEW MEXICO; III-VIII; at *Asclepias*, *Monarda stricta*, *Solidago trinervata*, *Sicyos parviflorus*, *Salvia lanceolata*, and (Cockerell, 1899*d*, p. 256) *Ungnadia speciosa*; (Mead, Townsend, Steel, Tinsley, Wooton, Cockerell, and Porter). "The vertical range is from 3800 to 8200 ft., but the insect seems to be most abundant at 6500-7500 ft."

Fowler, 1902, p. 312. Mount Shasta, CALIFORNIA; (Jones). ARIZONA.

Titus, 1902, p. 39. Fort Collins, Trinidad, Antonito (Gillette), Cerro Summit, Horsetooth Gulch, and Cimmaron, COLORADO; V-IX; at *Mentzelia multiflora*, *Helianthus annuus*; *Thermopsis montanus*, *Alnus viridis*, and wild rose.

B. perplexus Titus, 1902, p. 39. ♂.

Cockerell, 1906, p. 313. Pecos, NEW MEXICO. "Transition to Middle Sonoran."

Cockerell, 1906*d*, p. 453. Florissant, COLORADO; VI; (Rohwer).

Bombias morrisoni Swenk, 1907, p. 295. Warbonnet Canyon, Sioux County, and Gering, NEBRASKA; VII, VIII.

Cockerell, 1907*b*, p. 258. Boulder, COLORADO; V.

Tucker, 1909, p. 277. Colorado Springs, COLORADO; VIII.

Davidson, 1911, p. 66. Los Angeles, trail to Wilson's Peak, CALIFORNIA.

B. (Bombias) morrisoni Franklin, 1913, p. 431. UTAH. Chino, CALIFORNIA. Flagstaff, ARIZONA.

See *impatiens*.

nearcticus. See *edwardsii*.

neglectulus. See *californicus*.

neoboreus Sladen, 1919*a*, p. 28*g*. ♂, ♀, ♀. Bernard Harbour, NORTH-WEST TERRITORIES; VI-VIII; (Johansen).

[A.] **nevadensis** Cresson, 1874, p. 102. ♀*, ♂. NEVADA*, (Yarrow). ARIZONA, (Henshaw).

Cresson, 1875, p. 728. NEW MEXICO; (Yarrow).

B. improbus Cresson, 1878*a*, p. 188. ♂. COLORADO; (Morrison).

Cresson, 1879, p. 230. COLORADO. CALIFORNIA.

Cockerell, 1893, p. 338. Near Swift Creek, Custer County, COLORADO.

B. nevadensis cressoni Cockerell, 1899*a*, p. 338. ♀. WASHINGTON. COLORADO. White Mountains at 10,300 ft., South Fork, Eagle Creek at 8300 ft., North Fork of Ruidoso Creek at 8200 ft., Mescalero Indian Agency (typical form; 1899, p. 156), and Las Vegas, NEW MEXICO; VIII; at *Delphinium scopulorum*, *Sicyos parviflorus*, *Solidago trinervata*, and *Cleome serrulata*; (Townsend, Otis, Porter, and Cockerell).

B. improbus Cockerell and Porter, 1899, p. 389. South Fork of Eagle Creek, White Mountains, NEW MEXICO; 8200 ft.; VIII; at *Senecio rusbyi*.

Ashmead, 1902, p. 124. ALASKA. UTAH.

Titus, 1902, p. 40. Fort Collirs, Beaver Creek, Little Beaver Creek, Boulder, Bellvue, Antonito, Virginia Dale, and Livermore, COLORADO; V-VIII.

Viereck, 1902, p. 45. Beulah, NEW MEXICO.

Viereck *et al.*, 1904, p. 98. Condon, OREGON; VII; (Cordley).

Cockerell, 1906, p. 313. "Canadian to Upper Sonoran."

Cockerell, 1906*d*, p. 453. Florissant, COLORADO; VII; at *Polemonium*; (Rohwer).

Fletcher and Gibson, 1907, p. 129. Vernon, BRITISH COLUMBIA (?); McLeod and High River, ALBERTA; VI; (Venables, Fletcher, Willing, Baird).

Bombias nevadensis Swenk, 1907, p. 295. Dundy County, Sioux County, and West Point, NEBRASKA; V-IX; at *Astragalus*, *Malvastrum*, and *Monarda*.

Cockerell, 1910*a*, p. 25. Calgary, ALBERTA; VI.

Cockerell, 1910*d*, p. 128. Near Axial, COLORADO; at *Achillea*; (Robbins).

Davidson, 1911, p. 66. Los Angeles, on the trail to Wilson's peak, CALIFORNIA.

B. (Bombias) nevadensis Franklin, 1913, p. 416. Fort McLeod, BRITISH COLUMBIA. MONTANA.

Franklin, 1915, p. 414. Dickinson, NORTH DAKOTA; (Stevens).

See *auricomus*.

nevadensis aztecus. See *fervidus dorsalis*.

nidulans. See *americanorum*, *kirbyellus*, and *polaris*.

[D.] *niger* Franklin, 1913*a*, p. 120. ♀, ♂, ♂. Belize, BRITISH HONDURAS, Carillo and La Estrella de Cartago, COSTA RICA. Bogona and Boquete, Chiriqui, PANAMA. COLOMBIA. San Julian, VENEZUELA. ECUADOR. Callanga, PERU. Bonito in the Province of Pernambuco and St. Catharina, BRAZIL. Sapucay, PARAGUAY. Franklin notes that it may be the same as *velutinus* Illiger 1806, p. 175, or *violaceus* Lepeletier, 1836, p. 473.

Franklin, 1915, p. 415. Bugaba, PANAMA; (Champion). Monte Alegre, Lower Amazon, BRAZIL; (Austen).

nigrocinctus. See *crotchii*.

[D.] *nigrodorsalis* Franklin, 1907, p. 90. ♀*, ♂, and *nigrodorsalis latifrons* ♀. Meadow Valley (head of Rio Piedras Verdes, six miles south of Colonia Garcia, Sierra Madre of western Chihuahua), MEXICO; 7000 ft.; (Townsend).

B. laboriosus Smith, 1861, p. 153 (not Fabricius). ♂, ♀. Oaxaca, MEXICO. (See Meade-Waldo, 1916, p. 469.)

B. ehippiatus laboriosus Handlirsch, 1888, p. 233.

(?) *B. weisi* Friese, 1903, p. 253. ♂ (not ♂). San Carlos, COSTA RICA.

B. ehippiatus montezumæ Cockerell, 1908*b*, p. 344. New name.

B. montezumæ Franklin, 1913*a*, p. 95. Tlalpam, MEXICO.

Franklin, 1915, p. 410. Ciudad, Omilteme and Xucumanatlan (the two latter in Guerrero), MEXICO. Quezaltenago, GUATEMALA. All 7000-8100 ft., (Forrer, Smith, and Champion).

See *weisi*. *B. montezumæ* is probably a distinct variety.

nigroscutatus. See *occidentalis nigroscutatus*.

nivalis. See *kirbyellus*.

[T.] *occidentalis* Greene, 1858, p. 12. ♀, ♂. Northwest coast of America; Fort Vancouver (Cooper) and Puget Sound (Suckley).

B. modestus Smith, 1861, p. 153. ♀. Oaxaca, MEXICO. Franklin, 1913, p. 273 says that this locality is probably wrong.

B. proximus Cresson, 1863, p. 98. ♀. UTAH; (Suckley).

B. howardi Cresson, 1863, p. 98. ♂. Pikes Peak, COLORADO; (Howard). Cresson, 1879, pp. 230, 231. NEVADA. CALIFORNIA. OREGON. *B. howardii*: UTAH.

B. terricola howardi, *t. proximus*, and *t. occidentalis* Handlirsch, 1888, p. 234.

B. howardi Cockerell, 1898d, p. 71. Santa Fé Canyon, NEW MEXICO.

B. perixanthus Cockerell and Porter, 1896, p. 386, ♂. Harvey's Ranch, near Las Vegas, 9600 ft., and (*howardi*, p. 389) Beulah, and Monument Rock, Santa Fé Canyon, NEW MEXICO; at *Monarda* and *Rudbeckia*.

B. proximus howardi Cockerell, 1900a, p. 401. San Ignacio, NEW MEXICO; IX; (Porter).

B. howardii Viereck, 1901, p. 325. Eagle City, ALASKA; 65°, 30' N.; (Kirk).

B. proximus coloradensis Titus, 1902, pp. 38, 41. ♀. Rist Canyon, COLORADO; 6500 ft.; V. *B. proximus* (p. 41): Horsetooth Gulch, Virginia Dale, Fort Collins, Westlake, Home, Cimmaron, and Marshall Pass, COLORADO; IV-VIII. *B. howardii* (p. 41): Beaver Creek, 10,000-12,000 ft., VIII, and Ridgeway, COLORADO. (?) *B. terricola* (p. 42): Fort Collins, COLORADO; (Standard).

B. mckayi Ashmead, 1902a, p. 125. ♀. Nusha-gak River, ALASKA; (McKay).

B. howardi Ashmead 1902a, p. 125. Silver Lake, UTAH; VII.

Viereck *et al.*, 1904, p. 99. Corvallis and Mt. Hood, OREGON; V.

B. howardi Viereck, 1906, p. 238. Humphreys Peak, ARIZONA; 9500 ft.; VIII; (Snow).

B. proximus Cockerell, 1906, p. 313: top of Las Vegas Range, NEW MEXICO. *B. p. perixanthus*: Harvey's Ranch, NEW MEXICO, 9600 ft. *B. p. howardi*: San Ignacio, NEW MEXICO. "Hudsonian to Canadian" and (*howardi*) "Transition."

B. proximus coloradensis Swenk, 1907, p. 295. Warbonnet Canyon, Sioux County, NEBRASKA; VII; (Bruner).

B. proximus and *B. p. coloradensis* Cockerell, 1907b, p. 258. Boulder, COLORADO; V.

Fletcher and Gibson, 1907, p. 129. Banff, ALBERTA; VIII; (Sanston).

B. howardii and *proximus* Tucker, 1909, p. 277. Buffalo, COLORADO; VIII.

B. occidentalis howardii Cockerell, 1910d, p. 128. Ten miles east of Meeker, COLORADO; at *Solidago*; (Robbins).

Franklin, 1913, p. 265. "This species ranges through at least the greater portion of ALASKA (mouth of Dall River, Seldovia, Eagle and Nushagak River) and YUKON TERRITORY, through the greater part of BRITISH COLUMBIA (including Vancouver Island). . . It should be noted that I have no Canadian records for it distinctly east of the eastern limits of the Rocky Mountains, though it seems not improbable that it may range considerably further east."

Cockerell, 1913, p. 347. Feeding through puncture at base of "Chinese Cabbage" flower.

B. occidentalis perixanthus Cockerell, 1919d, p. 358. Miunehaha, Pikes Peak, COLORADO; (Frances Long).

Probably several of the named varieties, especially *perixanthus*, should be recognized as distinct varieties.

[T.] **occidentalis nigroscutatus** Franklin, 1913, p. 271. ♀, ♂, ♂. CALIFORNIA*. BRITISH COLUMBIA. MONTANA. COLORADO.

Fletcher and Gibson, 1908, p. 111; (Franklin Ms.). Skagway District of Northern BRITISH COLUMBIA; (White-Fraser).

oregonensis. See *frigidus*, *mixtus*, *silkensis*.

ornatus. See *melanopygus*, *sylicola*, *ternarius*, and p. 503.

pallidus. See *americanorum*.

parvulus. See p. 503.

pennsylvanicus. See *americanorum*, *auricomus*, *fervidus*, and *sonorus*.

perixanthus. See *occidentalis*.

[P.] **perplexus** Cresson, 1863, p. 91. ♂. CONNECTICUT; (Norton).

B. elatus Harris, 1835, p. 70. MASSACHUSETTS.

B. hudsonicus Cresson, 1863, p. 92. ♂. HUDSON BAY TERRITORY; (Norton).

Bowles, 1880, p. 33. Montreal, CANADA.

B. perplexus hudsonicus Cresson, 1887, p. 308.

Fletcher and Gibson, 1907, p. 129. Meach Lake, CANADA; VII; (Gibson).

Smith, 1910, p. 698. Brown's Mills, NEW JERSEY; VI; (Dæcke).

Franklin, 1913, p. 344. QUEBEC. ONTARIO. MANITOBA. NEW HAMPSHIRE. VERMONT. RHODE ISLAND. NEW YORK. PENNSYLVANIA. VIRGINIA. WEST VIRGINIA. NORTH CAROLINA. TENNESSEE. MICHIGAN. WISCONSIN. MINNESOTA. "The records of this species from Colorado . . . are erroneous." Nest.

Franklin, 1915, p. 414. Fargo, NORTH DAKOTA; (Stevens).

Lutz, 1916, p. 515. Mountains of GEORGIA; (Davis).

Viereck, 1916, p. 758. Branford and Westville, CONNECTICUT; V, VII.

Bequaert, 1920, p. 9. Wollaston, Auburndale, Arlington, and Sherborn, MASSACHUSETTS.

See *morrisoni*.

phaceliæ. See *rufocinctus*.

[P.] **pleuralis**, Nylander, 1848, p. 231. ♀, ♂. Sitka, ALASKA.

(?) *B. praticola* Kirby, 1837, p. 274. ♀. Lat. 65°.

Ashmead, 1902a, p. 127. Popoff Island and Kodiak, ALASKA; VII.
"Also found in SIBERIA."

B. justus Ashmead, 1902a, p. 127. Kukak Bay, Matlakatla, Nushagak River (McKay), and Wrangell (Wickham), ALASKA; VII.

B. kirbyellus pleuralis Friese, 1904b, p. 519.

(?) Cockerell, 1916c, p. 10. Whitefish Point, Chippewa County, MICHIGAN; VII; (Andrews).

Sladen, 1919a, p. 31g. ♂, ♀. Nome, ALASKA; (Johansen).

[K.] **polaris** Curtis, 1835, Pl. XIII. ♂, ♀. ARCTIC AMERICA. (See MEADE-WALDO, 1916, p. 469.)

Cresson, 1863, p. 101. Methy Portage, Arctic America.

MacLachlan, 1878, p. 106. Hayes Sound, lat. 79°; (Feilden).

Ashmead, 1902a, p. 127. Kodiak and Seldovia, ALASKA; VII.

B. nidulans Friese, 1904b, p. 519. Makes *polaris* a synonym.

Franklin, 1913, p. 298. Rama, Nain, Ft. Chimo, and Urgava, LABRADOR. McCormick Bay, GREENLAND. Considers Ashmead's, 1902a, p. 127, records from Kodiak and Seldovia, Alaska, doubtful.

Lutz, 1916, p. 520. Barrow, ALASKA; (Stefansson). Tupkak, in the delta of the MACKENZIE; (Anderson).

Bremus polaris Frison, 1919 p. 457. 76° 30' N. to 78° 20' N.; Crocker Land Expedition.

Sladen, 1919a, p. 27g. ♂, ♀, ♀. Nome (Johansen) and west of Collinson Point (Leffingwell), ALASKA; Kamarkok, west of Herschel Island, and Herschel Island (Johansen); Bernard Harbour, NORTHWEST TERRITORIES (Johansen).

praticolus. See *centralis*, *flavifrons*, *pleuralis*, *rufocinctus*, and p. 503.

proximus. See *occidentalis*.

prunellæ. See *cockerelli* and *rufocinctus*.

pulcher. See *formosus*.

putnami. See *kirbyellus*.

pyropygus. See *kirbyellus pyropygus*.

[F.] **ramonensis** Franklin, 1913a, p. 140. (*B. Bombias*) ♂. San Ramon, (?) COSTA RICA.

ridingsii. See *bimaculatus*.

[F.] **rubicundus** Smith, 1854, p. 400. ♀. COLOMBIA.

Handlirsch, 1888, p. 236. VENEZUELA.

B. bicolor Friese, 1903, p. 254. ♀. Cuenca, ECUADOR; 2200 m. Colom, MEXICO.

B. (Bombias) rubicundus Franklin, 1913a, p. 162. ♂. Callanga, PERU.

[F.] **rufocinctus** Cresson, 1863, p. 106. ♂*, ♀. Pikes Peak, COLORADO; (W. J. Howard).

B. ternarius (in part) Putnam, 1863, p. 99 and Packard, 1864, p. 117.

Bridport, VERMONT; the nest "under the clapboards of a house."

B. edwardsii Cresson, 1878a, p. 184. ♀, not ♀ and ♂. Localities doubtful, as it is not said where each sex came from.

Guignard, 1886, p. 68. Ottawa, CANADA.

B. praticola Provancher, 1888, p. 341. ♀, not the ♂. Ottawa, CANADA; (Guignard).

Cockerell, 1893, p. 338. West Cliff, Custer County, COLORADO; V, VIII; at *Gymnolomia multiflora*.

B. iridis Cockerell and Porter, 1899, p. 386. ♀. Beulah and Monument Rock (Santa Fé Canyon, 8000 ft.), NEW MEXICO; V, VIII; at *Iris missouriensis* and *Rudbeckia laciniata*; (Porter).

B. prunellæ Cockerell and Porter, 1899, p. 391 (the part from Beulah, NEW MEXICO).

(?) *B. ternarius* Cockerell, 1899, p. 156. Seattle, WASHINGTON; IV; (Kincaid).

B. edwardsii Titus, 1902, p. 41. Fort Collins, Bellvue, Rist Canyon, Westlake, and Barnes Camp (8000 ft.), COLORADO; VI-VIII.

Titus, 1902, p. 43. Horsetooth Gulch, COLORADO.

B. iridis Cockerell, 1904, p. 8. Pecos, NEW MEXICO; VI; at *Fallugia*.

B. iridis phaceliæ Cockerell, 1906b, p. 160. ♀. Ward, COLORADO; 9000 ft.; VII; at *Phacelia circinata*.

B. prunellæ Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VIII; (Snow).

B. iridis Cockerell, 1906, p. 313. "Canadian to Upper Sonoran."

B. edwardsii Cockerell, 1906d, pp. 453, 454. Florissant, COLORADO; VI; at *Edwinia*; (Rohwer). *B. iridis phaceliæ*: VII; at *Polemonium* and *Pedicularis*.

Bombias rufocinctus Swenk, 1907, p. 295. West Point, and Glen, Harrison, Pine Ridge and (*edwardsii*) Warbonnet Canyon, Sioux County, NEBRASKA; VII, VIII; at *Verbena*.

B. rufocinctus astragali Cockerell, 1907c, p. 97. ♀. Boulder, Ward, and Florissant, COLORADO; VI; at white *Astragalus* and at *Phacelia*; (W. P. and T. D. A. Cockerell, Rohwer).

Cockerell, 1907b, p. 257. Eldora, COLORADO; at *Gaillardia*. Also varieties *phaceliæ*, *iridis*, and *astragali*.

Fletcher and Gibson, 1908, p. 111. Radisson, SASKATCHEWAN, and Ottawa, CANADA; IX; (Fletcher).

Tucker, 1909, p. 277. Colorado Springs, COLORADO; VIII.

B. hyperboreus albertensis Cockerell, 1909c, p. 36. ♀. Calgary, ALBERTA; (Dod). See also Cockerell, 1913b, p. 110.

B. rufocinctus phaceliæ and *astragali* Cockerell, 1910a, p. 25. Calgary, ALBERTA; VI.

B. (Bombias) rufocinctus Franklin, 1913, p. 438. OREGON. CALIFORNIA. NEVADA. UTAH. Mescalera, NEW MEXICO. MONTANA. WYOMING. KANSAS. SOUTH DAKOTA. St. Paul, MINNESOTA. WISCONSIN. MICHIGAN. NEW YORK. TENNESSEE (?). QUEBEC. ONTARIO. MANITOBA. Regina, old territory of ASSINIBOIA.

Franklin, 1915, p. 414. Fargo, NORTH DAKOTA. Detroit, MINNESOTA; (Stevens).

B. rufocinctus astragali Cockerell, 1915b, p. 483. Tolland, COLORADO; at *Frasera stenosepala*.

B. rufocinctus castoris Cockerell, 1915, p. 537. ♂. Beaver Creek, MONTANA; 6300 ft.; VIII; (Hunter). Franklin's, 1913, "Variety 6."

B. rufocinctus phaceliæ Cockerell, 1919d, p. 358. Minnehaha, Pikes Peak, COLORADO; (Frances Long.)

Doubtless the several varieties should be recognized; some of them may even be distinct species.

rufosuffusus. See *huntii*.

sandersoni. See *vagans sandersoni*.

schmiedeknechti. See *terrestris moderatus*.

schneideri. See *ephippiatus*.

scutellaris. See *fraternus*.

[F.] *separatus* Cresson, 1863, p. 165. ♀*, ♀. PENNSYLVANIA. Rock Island, ILLINOIS; (Walsh). CANADA; (Saunders). *B. virginicus*, ♂, p. 87.

Cresson, 1864, p. 41. Northern NEW YORK; (Ashton).

Putnam, 1864, p. 101, and Packard, 1864, p. 114. Bridport, VERMONT. Boston, MASSACHUSETTS. Nest.

Putnam, 1876, p. 195, and Cresson, 1876, p. 210. Davenport, IOWA. Spring Lake, UTAH.

Bowles, 1880, p. 33. Montreal, CANADA.

Handlirsch, 1888, p. 229 (part). GEORGIA (?).

B. virginicus Provancher, 1888, p. 339. ♂. Quebec, CANADA.

Robertson, 1891a, pp. 569-596. Carlinville, ILLINOIS; at *Asclepias verticillata*, *incarnata*, *cornuti*, *sullivanti*, and *purpurescens*, *Acerates longifolia*, *Hydrophyllum appendiculatum*, *Mertensia virginica*, *Ipomœa pandurata*, *Collinsia verna*, *Gerardia pedicularis* and *tenuifolia*.

Robertson, 1894, pp. 436-475. Macoupin County, ILLINOIS; at *Prunus serotina*, *Rosa humilis*, *Pyrus coronaris*, *Crataegus crusgalli*, *Veronia fasciculata* (printed *noveboracensis* but changed by author in copies he sent out), *Lacinaria* ["*Liatris*"] *pycnostachya*, *Solidago canadensis* and *lanceolata*, *Aster novæ-angliæ*, *Silphium laciniatum*, *Echinacea purpurea*, *Rudbeckia triloba*, *Helianthus grosseserratus*, *strumosus*, and *tuberosus*, *Coreopsis aristosa*, *Helenium autumnale* and *Cnicus altissimus discolor* and *lanceolatus*.

Robertson, 1895a, pp. 142, 143. ♀, ♀. At *Frasera carolinensis* and *Phlox pilosa*.

Robertson, 1896, pp. 156, 160, 175, 178. At *Podophyllum peltatum*, *Æsculus*, *Astragalus canadensis*, *Aster ericoides villosus*, and *Rudbeckia laciniata*.

Robertson, 1898a, pp. 233, 236, 244. At *Cornus florida*, *Viburnum pubescens* and *Helianthus divaricatus*.

Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

Harris and Kucks, 1902, p. 36. Lake View, KANSAS; at *Cassia chamaecrista*.

Titus, 1902, p. 39. Fort Collins (Stannard) and Henderson (Gillette), COLORADO; VI-VIII.

Viereck, 1903a, p. 119. Boonsboro and Chestertown, MARYLAND; VIII; (Varatta).

Bombias separatus Robertson, 1903, pp. 176, 177.

Bombias separatus Viereck *et al.*, 1904, p. 97. Corvallis, Oregon; III-XI; (Cordley).

Grænicher, 1906, p. 14. Menomonee Valley, WISCONSIN; at *Sanguinaria canadensis*.

Grænicher, 1907, p. 93. ♀. At *Ribes cynosbati*.

Bombias separatus Swenk, 1907, p. 294. Lincoln, Omaha, Beatrice, South Bend, Weeping Water, Nebraska City, West Point, Neligh, Niobrara, Springfield, Gordon, and Sioux County, NEBRASKA; III-X; at *Prunus*, *Salix*, *Ribes*, *Rubus*, *Malus*, *Astragalus*, *Lonicera*, *Petalostemon*, *Psoralea*, *Verbena*, *Symphoricarpos*, *Monardia*, *Cassia*, *Solidago*, *Carduus*, and *Helianthus*.

Cockerell, 1907b, p. 258. Boulder, COLORADO; VIII; (W. P. Cockerell).

Tucker, 1909, p. 278. Lawrence, KANSAS; V.

Bombias separatus Smith, 1910, p. 699. Caldwell and Westville, NEW JERSEY. Staten Island, NEW YORK.

Cockerell, 1911, p. 391. Cuttyhunk Island, MASSACHUSETTS; VII.

Bombias separatus Grænicher, 1911, p. 249. Solon Springs in Douglas County, Randall and the mouth of the Yellow River in Burnett County, Hudson in St. Croix County, Prescott and Maiden Rock in Pierce County, and Fountain City in Buffalo County, WISCONSIN; VII, VIII.

B. (Bombias) separatus Franklin, 1913, p. 425. CONNECTICUT. RHODE ISLAND. DELAWARE. VIRGINIA. WEST VIRGINIA. OHIO. Detroit and Maple, MICHIGAN. INDIANA. KENTUCKY. Grand Rapids, WISCONSIN. MINNESOTA. MISSOURI. Charlotte and Raleigh, NORTH CAROLINA. SOUTH CAROLINA. GEORGIA. Capron and Miami, FLORIDA. ALABAMA. MISSISSIPPI. LOUISIANA. TENNESSEE. ARKANSAS. NORTH and SOUTH DAKOTA. MONTANA. WYOMING. IDAHO. Pasco, Wawawai, Almota, and Yakima City, WASHINGTON. Echo, OREGON.

Bombias separatus Viereck, 1916, p. 759. New Haven, CONNECTICUT.

Bequaert, 1920, p. 9. Sherborn, MASSACHUSETTS.

See *bimaculatus*.

[P.] *sitkensis* Nylander, 1848, p. 235. ♀, ♂, ♂. Sitka, ALASKA.

B. oregonensis Cresson, 1878a, p. 185. ♂. OREGON; (Edwards).

B. mixtuosus Ashmead, 1902a, p. 128. ♀, ♂. Popoff Island, Yakutat, Virgin Bay, and Fox Point, ALASKA; VI, VII.

(?) *B. mixtuosus* Viereck *et al.*, 1904, p. 99. Vancouver, BRITISH COLUMBIA; V, VI; (Harvey).

(?) *B. oregonensis* Viereck *et al.*, 1904, p. 99. Corvallis, OREGON; III-VIII; (Cordley). Vancouver, BRITISH COLUMBIA; V.

B. derhamellus sitkensis Friese, 1904b, p. 518.

Fletcher and Gibson, 1908, p. 111. Mt. Cheam, British Columbia, (Fletcher); and Skagway District of Northern BRITISH COLUMBIA, (White-Fraser).

Franklin, 1913, p. 377. Fort Wrangel, Seldovia, Juneau, and Urca, ALASKA. Comox and Metlakatla, BRITISH COLUMBIA. Mt. Rainier, Olympic Mountains, Seattle, and Pullman, WASHINGTON. Mt. Hood, OREGON. Lolo Trail and Bitter Root Mountains, IDAHO. Fieldbrook, CALIFORNIA.

See *alboanalis* and *frigidus*.

- [D.] **sonomæ** Howard, 1904, Pl. II, fig. 7. ♀. No text description; no locality. *B. "sonomæ"* was probably intended by Howard to be "*sonorus*" but was misprinted.

Franklin, 1913a, p. 133. ♀, ♂, ♂. Ealava and (Townsend) Meadow Valley (7000 ft.; at head of Rio Piedras Verdes, six miles south of Colonia Garcia, Sierra Madre of western Chihuahua), MEXICO.

sonorensis. See *sonorus*.

- [D.] **sonorus** Say, 1837. ♀. MEXICO.

B. pennsylvanicus Handlirsch, 1888, p. 238 (part). Puebla, Orizaba, Tacubaya, and Chapultepec, MEXICO.

B. sonorensis Fox, 1893, pp. 23, 120. San José del Cabo, Comondu, and El Taste (3400 ft.), Lower California, MEXICO; III; (Eisen, Haines).

B. pennsylvanicus sonorus Dalla Torre, 1896, p. 539.

Cockerell and Porter, 1899, p. 388. Rio Ruidoso in White Mountains at 6500 to 6900 ft. and Las Cruces, NEW MEXICO; VII, VIII; at *Monarda stricta*, *Verbascum thapsus*, *Vicia* near *pulchella*, *Prunella vulgaris*, *Mentzelia rusbyi*, *Rhus glabra*, and *Helianthus annuus*.

Cockerell, 1904, p. 8. Pecos, NEW MEXICO; VIII. Also, p. 234, San Pedro, CALIFORNIA, VII; at *Datura meteloides* and *Cæsalpinia gilliesi*.

Cockerell, 1906, p. 313. Mesilla Valley, NEW MEXICO. "Transition to Lower Sonoran."

Davidson, 1911, p. 66. CALIFORNIA: "Fairly common on the coast [near Los Angeles] and has been collected inland through the ranges around the Mohave desert to Inyo County and at Palm Springs in the Colorado desert."

Franklin, 1913, p. 407. Devil's River, Kerrville, Llano, and San Antonio, TEXAS. Silver City and Alamogordo, NEW MEXICO. Reef, Palmerlee and Huachuca Mountains, ARIZONA. San Luis, Cholula, San Luis Potosi, Morelia, and Guadalajara, MEXICO.

Franklin, 1915, p. 414. Northern Sonora, MEXICO; (Morrison). (?) Sonoma County, CALIFORNIA.

- [D.] **steindachneri** Handlirsch, 1888, p. 239. ♂, ♂. Yapanema, BRAZIL. Cuernavacca, MEXICO.

Franklin, 1913a, p. 105. ♀. Tacubaya, MEXICO.

Franklin, 1915, p. 414. MEXICO: Chilpancingo (4600 ft.), Amula (6000 ft.), Acaguizotla (3500 ft.), and Tepetlapa (3000 ft.), all in Guerrero, (Smith); Jallaco, in San Blas, and Tepic, (Schumann); and Ventanas (2000 ft.), (Forrer).

- [K.] **strenuus** Cresson, 1863. ♀*, ♂. Yukon River, ALASKA, and "Hudson Bay Territory"*; (Kennicott).

(?) *B. frigidus* Ashmead, 1902a, p. 126.

Franklin, 1913, p. 297. Fort Yukon and Fort Cosmos, ALASKA.

suckleyi. See *Psithyrus suckleyi*.

- [P.] **sylvicola** Kirby, 1837, p. 272. Lat. 65°, America.

(?) *B. ornatus* Smith, 1854, p. 398. ♀, ♂, (part). HUDSON BAY.

Cresson, 1863, p. 106. Yukon River and Great Slave Lake, CANADA; (Kennicott).

Cresson, 1879, p. 231. COLORADO.

(?) Bowles, 1880, p. 33. This Montreal record is probably erroneous.

Ashmead, 1902a, p. 127. Kukak Bay, Popoff Island, Seldovia, and Unalaska, ALASKA; VII, VIII.

Fletcher and Gibson, 1907, p. 129. Fullerton, HUDSON BAY Country; VI; (Hackett).

Franklin, 1913, p. 338. Nain and Rama, LABRADOR. Rigolet and Ungava Bay, UNGAVA. Point Barrow (Lat. 71°), ALASKA.

Lutz, 1916, p. 515. Langton Bay, NORTHWEST TERRITORY; (Anderson).

Sladen, 1919, p. 127. Makes it a synonym of the Eurasian *lapponicus* Fab.

Sladen, 1919a, p. 29G. ♀, ♂, ♂. Nome, and Teller, ALASKA. Herschel Island, YUKON TERRITORY. Bernard Harbour, NORTHWEST TERRITORY.

See *melanopygus*.

[P.] *sylvicola flavicollis* Friese, 1911, p. 572. (*B. lapponicus flavicollis*) Pikes Peak, COLORADO.

[P.] *sylvicola johanseni* Sladen, 1919a, p. 30G. ♀, ♂. Nome and Teller, ALASKA. Herschel Island, YUKON TERRITORY. Bernard Harbour, NORTHWEST TERRITORIES, (Johansen). Batrer Island (Jenness) and Collinson Point (Leffingwell), ALASKA. Fort Epworth, Coronation Gulf (O'Neill).

[P.] *ternarius* Say, 1837, p. 414. ♂. INDIANA; Franklin doubts the locality. A description of *ternarius* Harris, 1835, p. 70, *nom. nud.*, MASSACHUSETTS.

(?) *B. ornatus* Smith, 1854, p. 398. ♀, ♂, ♂, (part). HUDSON BAY.

Cresson, 1863, p. 104. ♀, ♂, ♂, (part). MAINE. CONNECTICUT. PENNSYLVANIA. The records for Kansas, Utah, Puget Sound, and Arctic America are doubtful.

Putnam, 1864, p. 99. Bridport, VERMONT. Nest.

Bowles, 1880, p. 33. Montreal and Quebec, CANADA.

B. ternarius ornatus Handlirsch, 1888, p. 230.

(?) Cockerell, 1893, p. 337. Willow Creek, Custer County, COLORADO; VIII.

Evans, 1896, p. 13. Sudbury, ONTARIO.

Harvey and Knight, 1897, p. 79. Jackman, MAINE.

Lovell, 1898a, pp. 383, 387, 389. At *Gaultheria procumbens*, *Cornus stolonifera* and *Aralia racemosa*.

Lovell, 1907, p. 197. Waldoboro, MAINE; IV-IX; at *Salix discolor* and *bebbiana*, *Aesculus hippocastanum*, *Rhodora canadensis*, *Gaylussacia resinosa*, *Rhus typhina*, *Solidago bicolor*, *Aralia hispida*, and *Eupatorium perfoliatum*.

Fletcher and Gibson, 1907, p. 129. Prince Albert, CANADA; VII; (Fletcher).

B. ternarius Grénicher, 1907, pp. 26, 36, 91, 93. ♀, ♂. WISCONSIN; at *Allium cernuum*, *Vagnera stellata*, *Ribes oxycanthoides* and *cynosbati*.

B. huntii ("=ternarius") Gränicier, 1911, p. 248. Solon Springs in Douglas County, Never's Dam in Polk County, and Fishtrap and the mouths of the Nemakagon and Yellow Rivers in Burnett County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 213. NEW HAMPSHIRE. NEW YORK. Jeannette, PENNSYLVANIA. WEST VIRGINIA. Grand Rapids, WISCONSIN. Minneapolis, St. Paul, and Lake Itasca, MINNESOTA. Bigstone, SOUTH DAKOTA. Tower City, NORTH DAKOTA. Hampton, PRINCE EDWARD ISLAND. Saguenay River, QUEBEC. Ottawa, ONTARIO. Winnipeg, MONTREAL. Oxbow, Regina, and Carnduff, SASKATCHEWAN. St. Albert and MacLeod, ALBERTA. There is no doubt but that the Barbados, W. I., record is either a mistake or due to an accident.

Crawford, 1913, p. 269. Red Head, St. John, Douglas Harbor, Grand Lake, and Nerepis, NEW BRUNSWICK; VII-IX.

Franklin, 1915, p. 414. Fargo and Medora, NORTH DAKOTA. Lake Park, MINNESOTA; (Stevens).

Lutz, 1916, p. 514. Battle Harbor, LABRADOR; (Leng). Lake Marcia, Sussex County, NEW JERSEY.

Cockerell, 1916c, p. 7. Floodwood, Schoolcraft County, and Whitefish Point, Chippewa County, MICHIGAN; VII; (Gaige, Andrews).

Bequaert, 1920, p. 9. Sherborn, MASSACHUSETTS. Colebrook, CONNECTICUT.

See *edwardsii*, *fervidus*, *huntii*, *melanopygus*, *mexicensis*, and *rufocinctus*.

ternarius bifarius. See *edwardsii*.

[P.] *ternarius expallidus* Cockerell, 1916c, p. 9. Floodwood, Schoolcraft County, MICHIGAN; VII; (Gaige).

ternarius lacustris. See *edwardsii*.

[T.] *terrestris moderatus* Cresson, 1863, p. 109. (*B. moderatus*) New name for *B. modestus* Cresson, 1863, p. 99 (not Smith). ♀. Yukon River, Arctic America; (Kennicott).

B. terrestris ferrugineus Schmiedeknecht, 1878, p. 359. ♀, ♂, ♂.

B. terrestris schmiedeknechti Meunier, 1888, pp. 173, 197. Franklin's page reference is wrong. See, however, Handlirsch, 1888a, p. 64.

B. terricola modestus Handlirsch, 1888, p. 234.

B. moderatus Ashmead, 1902a, p. 123. Kodiak, ALASKA; VII.

Fletcher and Gibson, 1908, p. 111. Banff, CANADA; (Sanson).

Franklin, 1913, p. 262. "This form ranges throughout the greater part of EUROPE and SIBERIA. In the New World, it appears to be confined to ALASKA, though it may possibly be found in the adjoining territory of Yukon. My Alaskan records are as follows: Point Barrow, Cosmos, Kukak Bay, Koyunkuk and Kodiak. I also have records from Petropaulski, Kamchatka and Bering Island."

Diven, 1916, p. 470. Maligne Lake, near Jasper, ALBERTA; VII.

Sladen, 1919, p. 127. Considers it to be a "form" of the Eurasian *lucorum*.

B. lucorum moderatus Sladen, 1919a, p. 31a. ♀. Nome, ALASKA; (Johansen).

terrestris terricola. See *terricola*.

[T.] *terricola* Kirby, 1837, p. 273. ♀. Lat. 65°, North America.

Cresson, 1863, p. 99. ♂; HUDSON BAY TERRITORY.

Cresson, 1864, p. 41. Northern NEW YORK; (Ashton).

Packard, 1864, p. 112. ♂. MAINE.

Bowles, 1880, p. 33. Quebec and Montreal, CANADA.

EVALS, 1896, p. 13. Sudbury, ONTARIO.

Harvey and Knight, 1897, p. 79. Jackman, MAINE.

Fletcher and Gibson, 1907, p. 129. Kebinakagami River, near height of land, HUDSON BAY slope; VIII; (Wilson).

Lovell, 1898a, p. 383, 385, 387-389. At *Gaultheria procumbens*, *Impatiens biflora*, *Cornus stolonifera* and *alternifolia*, and *Aralia racemosa*.

Lovell, 1907, p. 196. Waldoboro, MAINE; IV-VII; at *Salix discolor* and *bebbiana*, *Rhodora canadensis*, *Æsculus hippocastanum*, *Rosa humilis*, *Viburnum alnifolium*, *Gaylussacia resinosa*, *Aralia hispida*, *Solidago bicolor*, *Vicia cracca*, *Epilobium angustifolium*, and *Eupatorium perfoliatum*.

Titus, 1908, p. 317. Rock Harbor and Siskowit Bay, Isle Royale, MICHIGAN. His records from KANSAS and Colorado, and possibly the one from Illinois, are probably in error.

Cockerell, 1910a, p. 25. Calgary, ALBERTA; VI, VII.

B. terrestris terricola Friese and Wagner, 1910, p. 28.

Cockerell, 1911, p. 390. Woods Hole, MASSACHUSETTS; (Cattell).

Gräniche, 1911, p. 249. Solon Springs and St. Croix Dam in Douglas County, and Fishtrap, Randall, and mouths of the Nemakagon and Yellow Rivers in Burnett County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 274. All the NEW ENGLAND states except Rhode Island. Oneida, Keere Valley, and Long Island, NEW YORK. NEWFOUNDLAND. PRINCE EDWARD ISLAND. Ottawa, Lake of Bays, and Nepigon, ONTARIO. Arveme and Winnipeg, MANITOBA. Oxbow and Regina, SASKATCHEWAN. St. Albert and Edmonton, ALBERTA. Lake Itasca, MINNESOTA.

Crawford, 1913, p. 269. Red Head, St. John, and Nerepis, NEW BRUNSWICK; VII-X.

Franklin, 1915, p. 413. Fargo, NORTH DAKOTA. Detroit and Lake Park, MINNESOTA; (Stevens).

Lutz, 1916, p. 521. Ramsey, NEW JERSEY. Black Mountains, NORTH CAROLINA; (Beutenmuller). Boisedale, Cape Breton Island, Codroy, and Spruce Brook, NEWFOUNDLAND.

Viereck, 1916, p. 758. Branford and Colebrook, CONNECTICUT; V, VII.

Cockerell, 1916c, p. 10. Floodwood, Schoolcraft County, and Whitefish Point, Chippewa County, MICHIGAN; VII; (Gage, Andrews).

Bequaert, 1920, pp. 9, 10. Forest Hills, Auburndale, and Sherborn, MASSACHUSETTS. Essex Falls, Essex County, NEW JERSEY. As'oria, Long Island, NEW YORK.

Sladen, 1919, p. 126. Banff, ALBERTA. Compares it with *terrestris*. Says it is distinct from *occidentalis*.

See *occidentalis*.

titusi. See *americanorum*.

tricolor. See *kirbyeus*.

[P.] *trinominatus* Dalla Torre, 1890, p. 139. New name for *modestus* Smith, not Eversmann.

B. modestus Smith, 1861, p. 153. ♀, not ♂. Oaxaca, MEXICO. (See Meade-Waldo, 1916, p. 469.)

Franklin, 1915, p. 411. Omilteme, Guerrero, MEXICO; 8000 ft.; (Smith)

unifasciatus. See *medius* and *mexicanus*.

[P.] *vagans* Smith, 1854, p. 399. ♀. "North America."

Cresson, 1863, p. 91. ♂, ♂ (not ♀). CANADA. MAINE. CONNECTICUT. PENNSYLVANIA. NEW JERSEY. DELAWARE. DISTRICT OF COLUMBIA. VIRGINIA. ILLINOIS.

B. consimilis Cresson, 1864, p. 41. ♀. CANADA. NEW YORK.* MASSACHUSETTS.

Cresson, 1864, p. 41. Northern NEW YORK; (Ashton).

Packard, 1864, p. 115 (not the ♀). Warwick, MASSACHUSETTS. Chamberlain Lake at the headwaters of Penobscot River, MAINE.

(?) Bowles, 1880, p. 33. Quebec and Montreal, CANADA.

B. consimilis Provancher, 1883, p. 734.

Provancher, 1888, p. 339. Cap Rouge, CANADA.

Robertson, 1891a, pp. 571-595. At *Asclepias incarnata* and *purpurescens*, *Triosteum perfoliatum*, *Phlox divaricata*, *Polemonium reptans*, *Hydrophyllum virginicum* and *appendiculatum*, *Mertensia virginica*, *Linaria vulgaris*, *Scrophularia nodosa marilandica*, *Pentstemon pubescens*, *Veronica virginica*, *Seymeria macrophylla*, and *Gerardia pedicularia*.

Robertson, 1894, pp. 452, 455, 471. Macoupin County, ILLINOIS; at *Eupatorium serotinum*, *Solidago canadensis*, and *Helianthus tuberosus*.

B. consimilis Evars, 1896, p. 13. Sudbury, ONTARIO.

Harvey and Knight, 1897, p. 79. Jackman, MAINE.

Lovell, 1898, pp. 4, 5 (of separate). Waldoboro, MAINE; at *Sagittaria latifolia* and *Pontederia cordata*. 1898a, pp. 383, 385, 389; at *Gaultheria procumbens*, *Chelone glabra*, *Impatiens biflora*, and *Aralia racemosa*; also "*B. consimilis*" at the first two.

(?) *B. consimilis*, Viereck, 1901, p. 325. Eagle City (65° 31' N.), ALASKA; (Kirk).

B. consimilis Britton and Viereck, 1906, pp. 213, 217, 219. At *Ribes nigrum*, *Pyrus malus*, and *Cydonia vulgaris*.

B. consimilis Grænicher, 1907, pp. 23, 32, 36, 40, 42, 91, 94. ♀, ♀. WISCONSIN; at *Allium tricoccum*, *Asparagus officinalis*, *Clintonia borealis*, *Vagenera stellata*, *Salomonella biflora* and *commutata*, *Ribes oxycanthoides* and *gracile*.

B. consimilis Lovell, 1907, p. 198. Waldoboro, MAINE; V-IX; at *Salix bebbiana*, *Lonicera ciliata*, *Rhodora canadensis*, *Clintonia borealis*, *Rhus typhina*, *Epilobium angustifolium*, *Pontederia cordata*, *Falcata comosa*, *Trifolium pratense*, *Pontederia cordata*, *Epilobium angustifolium*.

B. consimilis, Swenk, 1907, p. 296. Lincoln, Omaha, South Bend, Weeping Water, Meadows, Cedar Bluffs, Nebraska City, Falls City and Nemaha City, NEBRASKA; at *Rubus*, *Lonicera*, and *Petalostemon*.

B. consimilis Titus, 1908, p. 317. Rock Harbor, Isle Royale, MICHIGAN. Fletcher and Gibson, 1908, p. 111. Restrevor, Muskoka, ONTARIO. Regina, SASKATCHEWAN. Banff, ALBERTA. Westbourne, MANITOBA. VIII, IX. (Gibson, Fletcher, Wallis).

B. consimilis Cockerell, 1910a, p. 25. Calgary, ALBERTA; VII; (Dod).

Cockerell, 1911, p. 390. Woods Hole, MASSACHUSETTS; (Cattell).

B. consimilis Grænicher, 1911, p. 249. Solon Springs, Gordon, St. Croix Dam, and Coppermine Dam in Douglas County, Swiss and mouths of Nemakagon and Yellow Rivers in Burnett County, Farmington in Polk County, Maiden Rock in Pierce County, and Fountain City in Buffalo County, WISCONSIN; VII, VIII.

Franklin, 1913, p. 349. NORTH CAROLINA. KENTUCKY. OHIO. INDIANA. St. Paul and Lake Itasca, MINNESOTA. IOWA. MISSOURI. KANSAS. NORTH and SOUTH DAKOTA. Eastern COLORADO. WYOMING. Missoula, Big Fork, and Ravalli County, MONTANA. Meach Lake, QUEBEC. Ottawa and Nepigon, ONTARIO. Nest.

Crawford, 1913, p. 269. St. John and Nerepis, NEW BRUNSWICK; VIII-X. Viereck, 1916, p. 757. Branford, Colebrook, Prospect, and Stonington, CONNECTICUT. He recognizes *consimilis* as a variety.

B. consimilis Cockerell, 1917e, p. 212. Falls Church, VIRGINIA; at *Helianthus annuus zonatus*.

Bequaert, 1920, p. 9. Forest Hills, Auburndale, Dedham, Boston, and Sherborn, MASSACHUSETTS.

See *affinis*.

[P.] *vagens sandersoni* Franklin, 1913, p. 353. ♀. Hanover and Durham, NEW HAMPSHIRE. Amherst, MASSACHUSETTS.

vancouverensis. See *edwardsii*.

veganus. See *flavifrons*.

velutinus. See *niger*.

violaceus. See *niger*.

virginicus. See *impatiens* and *separatus*.

vogti. See *volucelloides*.

[F.] *volucelloides* Gribodo, 1891, p. 119. ♀. Chiriqui, PANAMA. "Antioquia."

B. leucomelas Crawford and Swenk, 1903, p. 268. ♀, ♂. Cartago, Volcanso Irazu, and Monte Redonda, COSTA RICA; II-VI.

B. vogti Friese, 1903, p. 254. ♀. BOLIVIA. Callanga and Marcapata, PERU. Popayan, COLOMBIA.

B. (Bombias) volucelloides Franklin, 1913a, p. 155. Boquete, Chiriqui, PANAMA. Zarzero, COSTA RICA. ECUADOR. Chanchamayo, PERU. Tarata, BOLIVIA.

Franklin, 1915, p. 415. Omilteme, Guerrero, MEXICO; 8000 ft.; (Smith). Rio Sucio, COSTA RICA; (Rogers).

Friese, 1916, p. 298. San José, COSTA RICA; (Schmidt).

[P.] *vosnesenskii* Radoszkowsky, 1862. ♀, ♂. CALIFORNIA; (Vosnessensky).

B. californicus Smith, 1854, p. 400. ♂ (not ♀).

B. californicus Cresson, 1863, p. 97. ♀, ♂ (not ♀).

B. flavifrons Smith, 1866, p. 343. Vancouver Island, BRITISH COLUMBIA.

B. californicus Handlirsch, 1888, p. 243. Localities uncertain.

B. columbicus Dalla Torre, 1890, p. 139. N. n. for *flavifrons* Smith, not Cresson.

B. columbicus Cockerell, 1904e, p. 89. Los Angeles and Bear Valley, CALIFORNIA; (Davidson).

Cockerell, 1910, p. 27. San Gabriel Mountains, near Pasadena, CALIFORNIA; 1750 ft.; VII; (Grinnell).

Franklin, 1913, p. 325. OREGON. WASHINGTON. Orsmy County, NEVADA.

[F.] *weisi* Friese, 1903, p. 253. ♀ (?), ♂. San Carlos, COSTA RICA.

Var. *albocaudata*, BOLIVIA.

Friese, 1904a, p. 188. Banos, ECUADOR; (Hensch).

B. (Bombias) weisi. Franklin, 1913a, p. 148. San Antonio, COLOMBIA.

Friese's workers probably belong to *nigrodorsalis montezumæ*.

Franklin, 1915, p. 412. Huascary, PERU; 6500 ft.; (Townsend).

See *nigrodorsalis*.

[D.] *wilmattæ* Cockerell, 1912b, p. 21. (*B. lateralis wilmattæ*) ♀. Antigua* and Guatemala City, GUATEMALA; (W. P. Cockerell).

B. ephippiatus d Handlirsch, 1888, p. 233. GUATEMALA.

B. guatemalensis Franklin, 1913, pp. 196, 197. *Nomen nudum*.

Franklin, 1913a, p. 100. ♀, ♀. Quiché, GUATEMALA. ECUADOR.

Franklin, 1915, p. 414. Quezaltenago, GUATEMALA; 7800 ft.; (Champion).

Bremus Panzer

See *Bombus*.

CALYPTAPIS Cockerell, 1906e, p. 41

(Type: *Calyptapis florissantensis* Ckll.)

florissantensis Cockerell, 1906e, p. 42. Fossil. Florissant, Colorado; (No. 4933, S. H. Scudder). "Not far from certain species of the modern *Melissodes*."

Cockerell, 1908, p. 324. Fossil. Miocene Shales, Station 13 B. Florissant Colorado; (W. P. Cockerell). Shown to belong to the Bombidæ.

PSITHYRUS Lepeletier, 1832, p. 372

(Type: *Apis rupestris* Fabricius)

Apathus Newman, 1834, p. 404.

Like *Bombus*, this genus has been divided into groups, *Laboriosus*, *Ashtoni*, and *Fernaldæ*, which are indicated here by their initials. It has also been made a distinct family but there seems to be no excuse for higher than subfamily rank, and even this is very questionable.

alata. See *laboriosus* and *Bombus fervidus*.

[A.] **ashtoni** Cresson, 1864, p. 42. (*Apathus*) ♀. NEW YORK*; (Ash-ton). MAINE; (Packard). CANADA; (Saunders).

Apathus ashtoni Packard, 1864, p. 118. Brunswick, MAINE. Boston (?), MASSACHUSETTS.

Apathus ashtoni Bowles, 1880, p. 33. Quebec and Montreal, CANADA.

Apathus ashtoni Provancher, 1882, p. 268. Cap Rouge, CANADA.

Apathus ashtoni Provancher, 1883, Faun., Ent. Can. Hym., p. 736. [Have not seen.]

Apathus ashtoni Evans, 1896, p. 13. Sudbury, ONTARIO.

Dalla Torre, 1896, p. 565.

Bombus asptoni Harvey and Knight, 1897, p. 79. Jackman, MAINE, VIII.

P. variabilis Howard, 1904, Pl. II, fig. 35.

Lovell, 1907, p. 199. ♀, ♂. Waldoboro, MAINE; VI-VIII; at *Vaccinium*, *Solidago*, *Epilobium angustifolium*, and *Aralia hispida*.

(?) *P. latitarsus* Titus, 1908, p. 317. Rock Harbor, Isle Royale, MICHIGAN.

P. consultus Fletcher and Gibson, 1908, p. 11 (part). Regina, SASKATCHEWAN.

Smith, 1910, p. 698. Caldwell and (*variabilis*) Jamesburg, NEW JERSEY; VII.

Franklin, 1913, p. 466. ONTARIO. Meach Lake and Maisonneuve, QUEBEC. Hampton, PRINCE EDWARD ISLAND. Conway, Durham, and Twin Mountain, NEW HAMPSHIRE. VERMONT. Ithaca, NEW YORK. CONNECTICUT. PENNSYLVANIA. VIRGINIA. MINNESOTA.

Crawford, 1913, p. 269. Red Head and St. John, NEW BRUNSWICK; IX, X.

Franklin, 1915, p. 415. Fargo, NORTH DAKOTA. Lake Park, MINNESOTA. (Stevens).

Viereck, 1916, p. 760. New Haven, CONNECTICUT; VII.

Cockerell, 1916c, p. 8. Floodwood, Schoolcraft County, and Whitefish Point, Chippewa County, MICHIGAN; VII; (Gauge, Andrews).

Sladen, 1919, p. 127. A "form" of the Eurasian *vestalis*.

Bequaert, 1920, p. 10. Auburndale, Brookline, Cambridge, and Sherborn, MASSACHUSETTS.

[L.] **bicolor** Franklin, 1913, p. 460. ♀. Rociada, NEW MEXICO; (Cockerell).

Franklin, 1915, p. 413. Xucumanatlan, Guerrero, MEXICO; 7000 ft.

californicus. See *Bombus californicus*.

cevallia. See *Bombus americanorum*.

citrinus. See *laboriosus*.

consultus. See *ashtoni* and *insularis*.

contiguus. See *laboriosus*.

[L.] **crawfordi** Franklin, 1913, p. 464. ♀, ♂. Placer County, CALIFORNIA. OREGON.

elatus. See *laboriosus* and *Bombus americanorum*, *fervidus*, and *perplexus*.

- [F.] **fernaldæ** Franklin, 1911, p. 164. ♀. Orono, MAINE. Amherst, MASSACHUSETTS. Webster, Durham, Crawfords, Mt. Washington and Conway, NEW HAMPSHIRE. Ithaca, NEW YORK. Mt. Rainier, WASHINGTON. Kaslo and Metlakatla, BRITISH COLUMBIA. Nushagak and Sitka, ALASKA. Is, in part, the *P. insularis* Ashmead, 1902a, p. 130. Probably the ♀ of *tricolor*.

fraternus. See *Bombus fraternus*.

- [?] **guatemalensis** Cockerell, 1912b, p. 21. ♂. Guatemala City, GUATEMALA; (W. P. Cockerell).
- [L.] **insularis** Smith, 1861, p. 155. (*Apathus*) ♀. Vancouver Island, BRITISH COLUMBIA; (Lyall).

Bombus interruptus Greene, 1858, p. 11. ♀. N. W. coast of America. Fort Steilacoom*, WASHINGTON Territory. OREGON; VII. (Suckley).

Apathus insularis Cresson, 1863, p. 113, not the ♂. 1876, p. 210: Empire and Clear Creek, COLORADO; (Putnam).

Handlirsch, 1888, p. 248 (part).

Ashmead, 1902a, p. 130 (part).

Viereck, 1902, p. 45. Beulah, NEW MEXICO; VII, VIII; (Cockerell).

Morrill, 1903, p. 225. MONTANA. Durham, NEW HAMPSHIRE.

Viereck, *et al.*, 1904, p. 100. ♂, ♀. Corvallis, OREGON. Mt. Cheam, BRITISH COLUMBIA. IV, VI, VIII. (Cordley, Harvey).

Cockerell, 1906d, p. 453. Florissant, COLORADO; VI; at *Iris missouriensis*.

Viereck, 1906, pp. 238, 240, 242. Oak Creek Canyon, ARIZONA; VIII. Madgalena Mountains, NEW MEXICO; VII. Manitou Park, COLORADO. (Snow).

Swenk, 1907, p. 297. Sioux County, NEBRASKA.

P. interruptus Fletcher and Gibson, 1907, p. 129. Mount Edith, Banff, ALBERTA; VII; (Fletcher).

Cockerell, 1910a, p. 25. Calgary, ALBERTA.

Franklin, 1913, p. 455. Cloudercroft, NEW MEXICO. UTAH. Missoula, Gallatin County, Ravalli County, Big Fork, Bozeman, Bridger Canyon, and Sedan, MONTANA. Pullman, WASHINGTON. Ithaca, NEW YORK, Glacier and Kaslo, BRITISH COLUMBIA. Saguenay River, QUEBEC. (?) Berg Bay, ALASKA.

P. consultus Franklin, 1913, p. 459. New name for *Apathus insularis* Cresson, 1863, p. 113, ♂ var. *b.*; and *P. suckleyi* Fletcher and Gibson, 1908, p. 111. Mt. Arrowsmith, Kelowna, and Fort MacLeod, BRITISH COLUMBIA. Banff, ALBERTA. Regina, SASKATCHEWAN. Pullman, Blue Mountains, and Ellenburg, WASHINGTON. Missoula and Gallatin County, MONTANA. Logan, UTAH. Pagosa Peak, Ward, and Manitou Peak, COLORADO. Magdalen Mountains, NEW MEXICO.

P. consultus Cockerell, 1915b, p. 483. Tolland, COLORADO; at *Frasera stenosepala*.

Crawford, 1913, p. 270. Red Head, St. John, and Nerepis, NEW BRUNSWICK; VII, IX, X.

Sladen, 1915, p. 84. Agassiz, BRITISH COLUMBIA; VII; (Treherne). ♀ and ♂ (*consultus*) in nest of *Bombus flavifrons*.

Franklin, 1915, p. 415. Fargo, NORTH DAKOTA; (Stevens).

Cockerell, 1916c, p. 8. Floodwood, Schoolcraft County, and Whitefish Point, Chippewa County, MICHIGAN; VII; (Gauge and Andrews).

See *ashlonti*, *fernaldæ*, *suckleyi*, *tricolor* and *Bombus impatiens*.

interruptus. See *insularis* and *suckleyi*.

[L.] *intrudens* Smith, 1861, p. 154. (*Apathus*) ♀. Oaxaca, MEXICO.

Handlirsch, 1888, p. 248. Puebla, MEXICO; (Bilimek).

Franklin, 1915, p. 413. A female with two labels: "Santa Cruz" and "San Geronimo, Guatemala, (Champion)."

kodiakensis. See *Bombus kincaidii*.

[L.] *laboriosus* Fabricius, 1804, p. 352. (*Bombus*) "Carolina."

For *alata* and *elatus* see p. 502.

Apathus citrinus Smith, 1854, p. 385. ♂. United States.

Apathus laboriosus Cresson, 1863, p. 111. ♀. CANADA. CONNECTICUT.

Apathus contiguus Cresson, 1863, p. 112. ♂. CONNECTICUT. PENNSYLVANIA. DELAWARE.*

Apathus citrinus Cresson, 1863, p. 112. MASSACHUSETTS. CONNECTICUT. NEW YORK. ILLINOIS.

Apathus laboriosus Cresson, 1872, p. 284. Dallas County, TEXAS; (Boll).

Apathus laboriosus Cresson, 1879, p. 230. WEST VIRGINIA.

(?) *Apathus elatus* Bowles, 1880, p. 33. Montreal, CANADA.

Apathus laboriosus and *citrinus* Provancher, 1882, pp. 268, 269. Cap Rouge, CANADA. Have not seen Provancher, 1883, Faun. Ent. Can. Hymen., pp. 736, 737.

Psithyrus citrinus Handlirsch, 1888, p. 248.

Dalla Torre, 1896, p. 569.

Apathus laboriosus Robertson, 1891a, p. 569. At *Asclepias verticillata*.

Robertson, 1896a, p. 156. At *Ptelea trifoliata*.

Apathus elatus Birkman, 1899, p. 245. Fedor, Lee County, Texas.

Viereck, 1903a, p. 119. College Park, MARYLAND; X.

Lovell, 1907, p. 199. Waldoboro, MAINE; VII-IX; at *Pontederia cordata*, *Inula helenium*, *Carduus odoratus*, *Epilobium angustifolium*, and *Solidago*.

Swenk, 1907, p. 297. Lincoln and West Point, NEBRASKA; VIII-IX.

Fletcher and Gibson, 1907, p. 129. Ottawa, CANADA; IV; (Fletcher).

Smith, 1910, p. 698. Caldwell and (*elatus*) Anglesea, Jamesburg, and Monmouth County, NEW JERSEY; X.

Grænicher, 1911, p. 248. Maiden Rock, Pierce County, WISCONSIN; VII-VIII.

Franklin, 1913, p. 451. Montreal, Prince Edward Island, and Grand Manan Island, CANADA. NEW HAMPSHIRE. VERMONT. MARYLAND. VIRGINIA. Blowing Rock, Wilkesboro, and Bushnell, NORTH CAROLINA. TENNESSEE. KENTUCKY. OHIO. MICHIGAN. INDIANA. St. Paul and Lake Itasca, MINNESOTA. He does not include Texas; see Cresson, 1872, p. 284, and Birkman, 1899, p. 245.

Crawford, 1913, p. 270. Nerepis, NEW BRUNSWICK; VIII, IX.

Franklin, 1915, p. 415. Fargo and Kathryn, NORTH DAKOTA. Lake Park, MINNESOTA. (Stevens).

Viereck, 1916, p. 760. Branford and Salisbury, CONNECTICUT; VIII.

Cockerell, 1916c, p. 8. Whitefish Point, Chippewa County, MICHIGAN; VI; (Andrews).

Bequaert, 1920, p. 10. Forest Hills, Stony Brook Reservation, Auburndale, Brookline and Sherborn, MASSACHUSETTS; VII, VIII; at *Cephalanthus occidentalis*.

- [A.] **latitarsus** Morrill, 1903, p. 224. ♀. Gallatin County and Bozeman*, MONTANA; (Cooley).

Franklin, 1913, p. 469. Big Fork, MONTANA. Blue Mountains, WASHINGTON. Vancouver and Kaslo, BRITISH COLUMBIA. (?) Ithaca, NEW YORK. Probably the female of *suckleyi*.

Franklin, 1915, p. 416. Creede, COLORADO; 8844 ft.; (Hunter).

See *ashtoni*.

- [L.] **sololensis** Franklin, 1913a, p. 173. ♂. Olas de Moka, Solola, GUATEMALA.

- [A.] **suckleyi** Greene, 1860, p. 169. (*Bombus*) ♂ (according to Franklin, 1913, p. 471, but the original says ♀). PUGET SOUND; (Suckley).

Apathus insularis Cresson, 1863, p. 113, ♂, var. *a*.

P. interruptus Dalla Torre, 1896, p. 569 (part).

P. consultus Fletcher and Gibson 1908, p. 111 (part). Nelson and Mt. Cheam, BRITISH COLUMBIA.

Franklin, 1913, p. 471. Kalso and Duncan's, BRITISH COLUMBIA. St. Albert, ALBERTA. Missoula and Gallatin County, MONTANA. Moscow and Beaver Canyon, IDAHO. Beaver Range Mountains, UTAH; 8000 to 10,000 ft. Santa Clara County, CALIFORNIA. May be the male of *latitarsus*.

Franklin, 1915, p. 416. Creede, COLORADO; 8844 ft.; (Hunter).

- [F.] **tricolor** Franklin, 1911, p. 167. ♂. Fort Wrangle, Juneau, Sitka, and Fox Point, ALASKA. Banff, ALBERTA. Metlakatla, BRITISH COLUMBIA. Olympic Mountains, WASHINGTON. Ward and Pagosa Peak, COLORADO. Brant Lake and Otto, NEW YORK. Weymouth, NOVA SCOTIA; (Bolster). Durham, Webster, and Mt. Washington, NEW HAMPSHIRE. It is the *Apathus insularis*, ♂, var. *c* Cresson, 1863, p. 113, and (?) part of *P. insularis* Ashmead, 1902, p. 130. Probably the male of *fernaldæ*.

Cockerell, 1912f, p. 84. Eldora, COLORADO. Ward, Colorado, designated as the type locality.

- [L.] **variabilis** Cresson, 1872, p. 284. (*Apathus*) ♀*, ♂. Bosque County*, TEXAS; (Belfrage).

Dalla Torre, 1896, p. 573.

Apathus variabilis Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Cockerell, 1899, p. 157. Stillwater, OKLAHOMA; at *Prunus americana*; (Regnier). Baldwin, KANSAS; (Bridwell). Tuerto Mountain, near Santa Fé, NEW MEXICO; 8200 ft.; VIII; at *Senico*.

Swenk, 1907, p. 297. Lincoln, Ashland, Seward, and West Point, NEBRASKA; V-X; at *Rubus*, *Verbena*, *Liatris*, *Bidens*, *Solidago*, and *Carduus*.

(?) Gränicheer, 1911, p. 248. Solon Springs and Coppermine Dam in Douglas County, and the mouths of the Nemakagon and of the Yellow River in Burrctt County, WISCONSIN; VII-VIII.

Franklin, 1913, p. 461. Dallas, Cotulla, Austin, Trinity, Victoria, and Goldthwait, TEXAS. ALABAMA. ILLINOIS.

Franklin, 1915, p. 415. Fargo, NORTH DAKOTA, (Stevens). Orizaba, MEXICO.

See *ashtoni*.

vestalis. See *ashtoni*.

EUGLOSSIDÆ

Eufriesia Cockerell

See *Euglossa*.

Euglossa Latreille, 1802, p. 385

(Type: *Apis cordata* Linné)

Friese, 1899b, pp. 117-172, gives a monograph of the genus with redescriptions and keys. Duce, 1902a, and Schrottky, 1903, review Brazilian species and give keys. Schrottky, 1907, pp. 48-57, reviews biology, etc., of Paraguay species.

Centris Fabricius, 1804, p. 354, (Type: *Apis dimidiata* Fabricius) is a synonym of *Euglossa*, not of the anthophorid *Hemesia*, according to Schrottky. See the discussion, p. 549.

The following subgenera are recognized.

Eulema Lepeletier, 1841, p. 11. "*Eulema*," often used, is French vernacular; see Cockerell, 1906b, p. 166.

Eumorpha Friese, 1899b, p. 126, was proposed as a subgenus. Cockerell, 1904d, p. 357, noted that the name is preoccupied and, 1908c, p. 41, substituted **Eufriesia** (Type: *pulchra* Smith).

Glossura Cockerell, 1917e, p. 144. Type: *Euglossa piliventris* Guérin.

analis. See *cordata* and *nigrita*.

angulata. See *smaragdina*.

auripes. See *smaragdina*.

bicolor Duce, 1902a, pp. 566, 570. ♂, ♀. Pará, BRAZIL; at *Anthurium regale*.

Crawford, 1906, p. 158. ♀. Pozo Azul, COSTA RICA; V; (Carriker).

cærulescens Lepeletier, 1841, p. 11. ♂. Locality unknown.

Smith, 1874, p. 445. ♀, ♂. MEXICO.

Dalla Torre, 1896, p. 312, considered this species to be a synonym of *violacea* Blanchard. See also Duce, 1910, p. 367.

E. (Eumorpha) caerulea Friese, 1899b, p. 145. BRAZIL.
Schrottky 1903, p. 592. São Paulo, BRAZIL.
Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

cayennensis. See *fasciata*.

convexa and *connexa*. See *mexicana convexa*.

cordata Linné, 1758, p. 575. (*Apis*) Probably West Indies.

Latreille, 1802, p. 436.

Bremus cordata Jurine, 1807, p. 262.

Cnemidium viride Perty, 1833, p. 149.

Euglossa analis Westwood, 1840, p. 262.

E. (Euglossa) cordata Friese, 1899b, p. 134. "From MEXICO to Rio Janeiro."

Ducke, 1901, p. 31. Pará, BRAZIL; ♀ at *Solanum toxicarium*, and *Allamanda nerifolia*; ♂ at *Gongora maculata*.

Schultz, 1902, p. 153. Biology.

Ducke, 1902a, p. 569. ANTILLES. ♂ at *Sobralia sessilis* in Brazil. Figures of nest.

Ducke, 1902b p. 401. ♂ at *Gongora*, *Sobralia sessilis*, and *Anthurium regale*.

Schrottky, 1903, p. 589. Tampico, MEXICO. VENEZUELA. Bauru, São Paulo, BRAZIL.

Ducke, 1903, p. 370. Biology.

E. cordata townsendi Cockerell, 1904a, p. 24. ♂, ♀. Vicinity of San Rafael, Vera Cruz, MEXICO; (Townsend).

Crawford, 1906, p. 158. Guapiles, COSTA RICA; 1000 ft.; V. A color variety at Pozo Azul, Costa Rica; VI; (Carrikér). Nests.

Schrottky, 1907, pp. 50, 67. Asunción, PARAGUAY; II, XII. Biology.

Cockerell, 1910, p. 418. JAMAICA; (Swainson).

Cockerell, 1912, p. 61. Porto Velho, Itacoatiara, Abuná, and Madeira-Mancoré R. R. Camp 41, BRAZIL; IX; (Mann and Baker).

Cockerell, W. P., 1912, p. 282. Gualan, GUATEMALA; ♂; at *Arthrostemma fragile*.

Cockerell, 1913a, p. 192. Quirigua, GUATEMALA; (W. P. Cockerell). "Variety *townsendi*, Ckll., is not separable."

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

Cockerell, 1917e, p. 146. Bahia, BRAZIL. ECUADOR.

See *variabilis*.

cyanura Cockerell, 1917e, p. 146. ♀. Porto Bello, PANAMA; II; (Busck).

dimidiata Fabricius, 1793, p. 316. (*Apis*) DUTCH GUIANA.

Centris dimidiata Fabricius, 1804, p. 354.

Bremus dimidiatus Jurine, 1807, p. 362.

Latreille, 1809, p. 180.

Eulema dimidiata Lepeletier, 1841, p. 12.

For other early references, see Dalla Torre, 1896, p. 310.

E. (Eulema) dimidiata Friese, 1899b, p. 164. MEXICO. PANAMA. ECUADOR. BOLIVIA. VENEZUELA. FRENCH GUIANA. Pará, Pernambuco, and Bahia, BRAZIL.

Ducke, 1901, p. 32. ♀ at *Oncoba pauciflora*; ♂ at *Catasetum tridentatum* and *macrocarpum*.

Ducke, 1902a, p. 576. At *Polygala spectabilis*.

Schrottky, 1903, p. 598. Chiriqui, PANAMA.

Eulema dimidiata Cockerell, 1912, p. 61. Matto Grosso, BRAZIL; IX; (Mann and Baker).

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

dimidiata quadrifasciata Friese, 1903a, p. 575. ♂, ♀. San Carlos, COSTA RICA.

elegans Lepeletier, 1841, p. 13. (*Eulæma*) ♀. FRENCH GUIANA.

Smith, 1874, p. 442. ♂. Santarem and Chontales, BRAZIL.

E. (Eulema) elegans Friese, 1899b, p. 158. DUTCH GUIANA.

Friese, 1900a, p. 122. Flies with *limbata* in VIII at Pará, BRAZIL.

Ducke, 1901, p. 31. ♀ at *Solanum toxicarium*, *Cassia alata* and *hoffmannseggii*.

Ducke, 1902a, p. 575. NICARAGUA. Belem, Anajas, and Macapá, Pará, BRAZIL; VI.

fasciata Lepeletier, 1841, p. 12. (*Eulæma*) ♀, ♂. FRENCH GUIANA.

Eulema cayennensis Lepeletier, 1841, p. 14. ♂. French Guiana.

See Smith, 1874, p. 442.

Eulema fasciata Fox, 1895, p. 272. Tepic, MEXICO.

E. (Eulema) fasciata Friese, 1899b, p. 163. MEXICO. HONDURAS. COLOMBIA. VENEZUELA. PERU. Pará and Pernambuco, BRAZIL.

Ducke, 1901, p. 31. ♀ at *Solanum toxicarium*, *Oncoba pauciflora*, *Bixa orellana*; ♂, *Cassia alata*, *Catasetum tridentatum* and *macrocarpum*; and, ♂, ♀, *Polygala spectabilis* and *Ischnosiphon*.

Eulema fasciata Crawford, 1906, p. 158. Pozo Azul (VI; Carriker), Guapiles (1000 ft.; III), and San José, COSTA RICA.

Cockerell, 1913a, p. 191. Antigua and Quirigua, GUATEMALA; (W. P. Cockerell).

ignita Smith, 1874, p. 444. ♂. JAMAICA.

E. (Euglossa) ignita Friese, 1899b, p. 137. Chiriqui, PANAMA. VENEZUELA. PERU. BRAZIL. Suggests that it may be a variety of *piliventris*.

Ducke, 1902b, p. 402. ♂ at *Catasetum* and *Stanhoepa eburnea*.

Cockerell, 1910, p. 418. ECUADOR; (Rosenberg).

E. (Glossura) ignita Cockerell, 1917e, p. 144.

leucopyga Friese, 1898, p. 203. (*Eulema*) ♀. COLOMBIA. May be *terminata* Smith, according to Friese, 1899b, p. 159.

E. (Eulema) leucopyga Friese, 1903a, p. 574. ♂. COSTA RICA; (Schild).

mexicana Mocsáry, 1897, p. 444. (*E. Eulema*) ♀, ♂. Præsidio, MEXICO.

Friese, 1899b, p. 151. Minas Geraës, BRAZIL. Suggests that it may be a variety of *smaragdina* Perty.

mexicana concava Friese, 1899b, p. 151. ♂. NICARAGUA.

Ducke, 1902a, p. 574. Pará, BRAZIL; ♀ at *Cassia alata*.

mexicana convexa Friese, 1899b, p. 151. ♀. BRAZIL.

Eulema m. convexa [misspelled "*connexa*"] Crawford, 1906, p. 158. Guapiles, COSTA RICA; 1000 ft.; III.

mixta. See *variabilis mixta*.

mussitans Fabricius, 1787, p. 301. (*Apis*)

Centris surinamensis Fabricius, 1804, p. 355.

Bremus surinamensis Jurine, 1807, p. 262.

Euglossa surinamensis Klug, 1807, p. 226.

Eulema surinamensis Lepeletier, 1841, p. 13.

Euglossa surinamensis Friese, 1899b, p. 160. Mexico to Brazil.

E. (Eulema) surinamensis Schrottky, 1902, p. 327. Northern Brazil.

Euglossa surinamensis, Schrottky, 1903, p. 597. Rio de Janeiro and Pará, BRAZIL. BRITISH GUIANA. FRENCH GUIANA. VENEZUELA. COLOMBIA. HONDURAS.

Eulema surinamensis Cockerell, 1904a, p. 23. Vicinity of San Rafael, Vera Cruz, MEXICO; III; (Townsend).

Cockerell, 1907c, p. 49. "This has been referred by all recent writers to *E. surinamensis*, based on *Apis surinamensis*, L., Syst. Nat., p. 579, No. 36. It is not, however, *A. surinamensis*, L., Syst. Nat., p. 575, No. 6, . . . This latter is a wasp, doubtfully identical with *Zethus mexicanus* (L., 1767). Friese has described a variety from Venezuela, which will stand as *Eulema mussitans nigrifacies* (Friese)." See *nigrifacies*.

Eulema mussitans Cockerell, 1912, p. 106. Guatemala City, GUATEMALA; XII; (Wheeler).

Eulema mussitans Cockerell, 1913a, p. 191. Quirigua, GUATEMALA; at a "big pea"; (W. P. Cockerell).

nigrifacies Friese, 1900a, p. 121. Includes the following.

Euglossa surinamensis Meunier, 1890, p. 63. ♀. Quito, ECUADOR.

Eulema surinamensis nigrifacies Friese, 1898, p. 205, and 1899b, p. 160. ♂. St. Parime, VENEZUELA.

E. (Eulema) panamensis Mocsáry, in Friese, 1899b, p. 169. ♀. Chiriquí, PANAMA.

nigrita Lepeletier, 1841, p. 14. (*Eulema*) ♀. FRENCH GUIANA.

Eulema analis Lepeletier, 1841, p. 14. ♂. BRAZIL.

Smith, 1874, p. 446.

E. (Eulema) nigrita Friese, 1899b, p. 157. Piahy and Minas Geraës, BRAZIL. Tarapoto, PERU. PANAMA.

Ducke, 1901, p. 50. Pará, BRAZIL; ♀, ♂; at *Centrosema plumieri* and *brasilianum*.

Ducke, 1902a, p. 576. Rio de Janeiro and São Paulo, BRAZIL. See also 1903, p. 371, and other papers.

Schrottky, 1903, p. 596. Flower and Brazilian records.

Centris nigrita Schrottky, 1907, p. 60. PARAGUAY. Biology.

Eulema nigrila Cockerell, 1919, p. 211. "Bogova, Chirique" (Panama?; (Rosenberg).

panamensis. See *nigrifacies*.

piliventris Guérin, 1845, p. 458. ♀, ♂. Pará, BRAZIL.

Fox, 1891, p. 348. Bog Walk, Parish of St. Catherines, JAMAICA.

E. (Euglossa) piliventris Friese, 1899b, p. 136. Bogota, COLOMBIA. DUTCH GUIANA. FRENCH GUIANA. PERU.

Ducke, 1901, p. 31. ♀ at *Solanum toxicarium*, *Oncoba paniciflora*; ♀, ♂. *Polygala spectabilis* and *Ischnosipon* sp.; and ♂ at *Catasetum tridentatum* and *macrocarpum*.

E. (Glossura) piliventris Cockerell, 1917e, p. 144. Bartica, BRITISH GUIANA; V. Maroni, FRENCH GUIANA.

See *ignita*.

purpurea. See *variabilis purpurea*.

quadrifasciata. See *dimidiata quadrifasciata*.

rugosa Friese, 1899b, p. 152. (*E. Eulema*) ♀. Cordoba, MEXICO.

semirufa. See *speciosa*.

smaragdina Perty, 1833, p. 150. (*Centris*) ♂. Prov. Minarum, BRAZIL.

E. smaragdina Smith, 1854, p. 382.

See Smith, 1874, p. 445.

Cockerell, 1899b, p. 17. Gives BAY OF CAMPECHE as type locality.

E. Eulema smaragdina Friese, 1899b, p. 148. Suggests that *auripes* Gribodo, *mexicana* Mocsáry, and *angulata* Mocsáry are merely varieties.

Friese, 1900a, p. 122. MEXICO. Pará and Pernambuco, BRAZIL.

Ducke, 1901, p. 32. At *Ipomæa*, *Allamanda neriifolia*, *Bixa orellana*, *Cassia alata*, *Centrosema plumieri* and *brasilianum*.

Ducke, 1902a, p. 573. MEXICO to Minas Geraes, on the supposition that *mexicana* is a synonym. Figures of nest and larva.

Ducke, 1903, p. 370. Biology.

See *mexicana*.

speciosa Mocsáry, 1897, p. 445. (*E. Eulema*) ♀. Chiriqui, PANAMA ("America centralis").

Eulema semirufa Friese, 1898, p. 204. ♂; Chiriqui, PANAMA.

surinamensis. See *mussitans* and *nigrifacies*.

terminata. See *leucopyga*.

townsendi. See *cordata*.

variabilis Friese, 1899b, p. 135. ♂, (?) ♀. CENTRAL and SOUTH AMERICA.

Schrottky, 1903, p. 590. Bahia, BRAZIL.

Cockerell, 1917e, p. 145, discusses synonymy, including Ducke's suggestion to sink *variabilis* in favor of *cordata*.

variabilis mixta Friese, 1899b, p. 135. ♂, ♀. BOLIVIA. Bahia, BRAZIL. Chiriqui, PANAMA.

Cockerell, 1917e, p. 145. Tabernilla, VII, and Cabima, V, (Busck) and Las Cascada (Jennings), near the Canal, PANAMA.

variabilis purpurea Friese, 1899b, p. 135. ♂. Chiriqui, PANAMA.

Cockerell, 1917e, p. 145. Sixola River (Schaus) and Pozo Azul (Carriker), COSTA RICA; VI.

viride. See *cordata*.

viridissima Friese, 1899b, p. 136. ♀, ♂. Cordoba and Orizaba, MEXICO; at *Stanhopea tigrina*.

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

Eulæma

See *Euglossa*.

Eumorpha

See *Euglossa*.

Glossura

See *Euglossa*.

ANTHOPHORIDÆ

Three subfamilies, which may for the present be called Centrinæ, Anthoporinæ, and Eucerinæ, are recognized. See Cockerell, T. D. A. and W. P., 1901, p. 46.

CENTRINÆ

Anthophorula Cockerell

See *Exomalopsis*.

CENTRIS Fabricius, 1804, p. 354.

One view is that Schrottky (1905, p. 13; 1909a, p. 160; and 1914, p. 220) is right in saying that, according to strict rules, "*Centris*" should not be applied to these anthophorid bees.¹ (See *Euglossa*.) Schrottky insists on using "*Hemisía*" for the present genus but "*Trachina*" does not seem to have been ruled out. Friese, 1900, used the name *Centris* and divided the genus into a number of subgenera, but left no typical subgenus. Here, as in certain other genera of bees, would seem to be a fitting place for name "conservation."

The following genera or subgenera have been proposed.

Trachina Klug, 1807, pp. 210-213, 266. (Type: *longimana* Fab.)

¹This is not clear to me. Schrottky says that no Anthophorid *Centris* has "clypeus gibbosus; tibiis posticis incrassatis, compressis, ciliatis"; but these words apply excellently to such a species as *Centris americana* Klug. As Fabricius mixed several genera in his *Centris*, later authors were at liberty to select a non-euglossid type, such as *C. versicolor* Fabricius.—T. D. A. C.

Hemisia Klug, 1807, pp. 213, 215, 227. (Type: *hæmorrhoidalis* Fab. See Cockerell, 1906, p. 105.)

Ptilotopus Klug, 1810, p. 31.

Heterocentris Cockerell, 1899, p. 14. (Type: *cornuta* Cress.)
N. n. for *Gundlachia* Cresson, 1865, p. 194.

Melanocentris Friese, 1900, p. 241, 244.

Rhodocentris Friese, 1900, pp. 242, 244. (See Cockerell, 1904d, p. 357.)

Cyanocentris Friese, 1900, pp. 243, 244.

Pacilocentris Friese, 1900, p. 244.

Fox, 1899, pp. 63-71, describes a number of new species and gives notes on already described ones. Friese, 1900, pp. 237-350, brings together the original descriptions of all of the species and gives keys, etc.

See also *Epicharis*.

abdominalis. See *agilis abdominalis*.

æthiops Cresson, 1865, p. 193. ♀. CUBA.

Centris (Melanocentris) æthiops Friese, 1900, pp. 242, 268.

Centris (Ptilotopus) æthiops Cockerell, 1906, pp. 73, 97.

See *armillata*.

agilis Smith, 1874, p. 361. ♂. Vera Cruz, MEXICO.

Centris (Rhodocentris) agilis Friese, 1900, pp. 243, 307. *C. ignita* may be the ♀. Orizaba, MEXICO. Piauh, VENEZUELA (Brazil?).

Centris (Trachina) agilis Cockerell, 1906, p. 97.

agilis abdominalis Friese, 1899, p. 45. ♀. Piauh, VENEZUELA (Brazil?).
Vera Cruz, MEXICO.

albiceps. See *mexicana albiceps*.

apicalis. See *smithii* and *versicolor apicalis*.

armillata Cresson, 1869, p. 298. ♂. CUBA.

Centris (Melanocentris) armillata Friese, 1900, pp. 242, 268. Probably the ♂ of *æthiops*.

* *Centris (Ptilotopus) armillata* Cockerell, 1900, p. 97.

aterrima Smith, 1854, p. 378. ♂. MEXICO.

Centris (Melanocentris) aterrima Friese, 1900, pp. 241, 267. ♂, ♀.

Centris (Ptilotopus) aterrima Cockerell, 1906, p. 97.

atra. See *xylocopoides*.

atripes Mocsáry, 1899, p. 254. ♂. Præsidio, MEXICO.

Centris atriventris Fox, 1899, p. 68 (not of Mocsáry). ♀, ♂; TEXAS and (?) Lower California, MEXICO.

Centris (Melanocentris) atripes Friese, 1900, pp. 242, 296. Near *birkmanni*. *Centris fori* Friese, 1900, pp. 350. N. n. for *atriventris* Fox.

Centris atripes Cockerell, 1904, p. 235. Beeville, TEXAS; VIII; (Townsend).

Centris (Ptilotopus) atripes and *foxi* Cockerell, 1906, pp. 97, 314. Douglas, ARIZONA. "Lower Sonoran."

Centris atripes Cockerell, 1906a, p. 72. San Bernardino Ranch, ARIZONA; VIII; (Snow).

atriventris. See *atripes*.

atriventris rubripes Friese, 1899, p. 43. ♂; VENEZUELA. ♀; PANAMA and BRAZIL.

Centris (Melanocentris) atriventris rubripes Friese, 1900, pp. 242, 287.

Centris (Ptilotopus) atriventris rubripes Cockerell, 1906, p. 97.

See *atripes*.

bakerella Friese, 1912a, p. 89. N. n. for *Centris (Hemisia) bakeri* Friese, 1912, p. 199. ♂; Morelos and Guadalajara, MEXICO; (Baker).

bakeri. See *bakerella*.

bicolor Lepeletier, 1841, p. 163. ♀. "Capt. de Goyan," BRAZIL.

Friese, 1900, p. 288. ♀, ♂. Minos Geraës, Espirito Santo, Rio Grande do Sul, Jundiáhy and Ypanema, BRAZIL. FRENCH GUIANA.

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

See *Epicharis*.

bicolorella. See *smithii*.

bimaculata Lepeletier, 1841, p. 168. ♀. São Paulo, BRAZIL.

(?) *C. fuscata* Lepeletier, 1841, p. 167. ♂. São Paulo, BRAZIL. If this is really the same, it has page-priority.

Burmeister, 1876, p. 163. Congonhas and Lagoa Santa (Minas Geraës), BRAZIL.

C. (Rhodocentris) bimaculata Friese, 1900, pp. 243, 306. CENTRAL and SOUTH AMERICA, "überall."

Schrottky, 1902, p. 323. Nueva Palmira, URUGUAY.

Cockerell, 1919, p. 188. El Rancho, GUATEMALA; I; (Deam).

birkmanni Friese, 1899, p. 44. ♂, ♀. Fedor, TEXAS; IV-VI; (Birkman). See Birkman, 1899, p. 245.

Centris (Melanocentris) birkmanni Friese, 1900, pp. 242, 296.

Centris (Ptilotopus) birkmanni Cockerell, 1906, p. 97.

See *atripes*.

breviceps Friese, 1899, p. 44. ♂, ♀. Minas Geraës, Amazon, BRAZIL.

Centris (Rhodocentris) breviceps Friese, 1900, pp. 243, 301. URUGUAY. COLOMBIA. PERU. BOLIVIA. Chiriqui, PANAMA. May be *villata* Lepeletier, 1841, p. 168.

Cockerell, 1919, p. 190. Rio Mato, Caura district, VENEZUELA; X; (Carriker).

cæsalpinia Cockerell, 1897, p. 394. ♀, ♂. Mesilla Valley, NEW MEXICO; V; at *Hoffmanseggia [Cæsalpinia] falcaria*.

Cockerell, 1898f, p. 314. Las Cruces, NEW MEXICO; at *Cevallia sinuata*.

Centris (Melanocentris) caesalpiniae Friese, 1900, pp. 242, 294, 341.

Centris (Ptilotopus) caesalpiniae Cockerell, 1906, p. 97.

See *rhodopus*.

chilensis. See *smithii*.

citrotæniata. See *flavifrons*.

clypeata Friese, 1899, p. 41. ♀, ♂. Orizaba, MEXICO. GUATEMALA.

II.

Centris (Melanocentris) clypeata Friese, 1900, pp. 241, 268. Orizaba and Cornuavacca (Cuernavacca?), MEXICO; II.

Centris (Ptilotopus) clypeata Cockerell, 1906, p. 97.

Centris clypeata Cockerell, 1913a, p. 192. Antigua, GUATEMALA; (W. P. Cockerell).

cockerelli Fox, 1899, p. 68. N. n. for ♀ (not ♂) *Centris hoffmannseggia* Cockerell, 1897, pp. 395, 397. College Farm, Mesilla Valley, NEW MEXICO; V; at *Hoffmanseggia*.

Centris cockerelli Cockerell, 1900, p. 363. Suggests that it is probably *lanosa* ♀.

Centris cockerelli Cockerell, 1904e (1905), p. 160. Palm Spring, CALIFORNIA: (Davidson).

Cockerell, 1919, p. 187. San José de Guaymas, MEXICO; IV; (Howard).

confinis Pérez, 1905, p. 40. ♀. MEXICO (?).

cornuta. See *difformis*.

costaricensis Crawford, 1907, p. 21. N. n. for *C. friesei* Crawford, 1906, p. 158. ♀. Guacimo, COSTA RICA; nests between the boards of a porch-roof.

crassipes Smith, 1874, p. 372. ♂. JAMAICA.

See Fox, 1891, p. 348.

Centris (Cyanocentris) crassipes Friese, 1900, pp. 244, 322.

Centris (Hemisia) crassipes Cockerell, 1906, p. 98.

davidsoni. See *hoffmannseggia davidsoni*.

decolorata Lepeletier, 1841, p. 160. ♂. Habitat unknown.

Centris decolorata Smith, 1874, p. 364. BRAZIL. MEXICO. SANTO DOMINGO.

Centris (Cyanocentris) decolorata Friese, 1900, pp. 243, 325. Adds PARAGUAY and describes a ♀, proposing to call it *obscuriventris* [q. v.] in case he has mistaken *decolorata*.

Centris (Hemisia) decolorata Cockerell, 1906, p. 98.

See *versicolor*.

dentipes. See *lanipes*.

difformis Smith, 1854, p. 374. ♀. Rio Tapajos, BRAZIL.

Centris ? cornuta Cresson, 1865, p. 194. ♀. CUBA. Suggests new genus. *Gundlachia*.

Cresson, 1879, p. 229. MEXICO.

Centris (Rhodocentris) difformis Friese, 1900, pp. 243, 300. FRENCH GUIANA.

Centris difformis Crawford, 1906, p. 158. Pozo Azul, COSTA RICA; (Carriker).

Centris (Heterocentris) difformis Cockerell, 1906, p. 97.

domingensis Dalla Torre, 1896, p. 304. N. n. for *C. thoracica* Smith (not Lepeletier), 1874, p. 370. ♀. SANTO DOMINGO.

Centris (Melanocentris) domingensis Friese, 1900, pp. 242, 288.

Centris (Ptilotopus) domingensis Cockerell, 1906, p. 97.

eiseni Fox, 1893, p. 22. ♀. Guaymas, MEXICO; V; (Eisen).

Centris (Pacilocentris) eiseni Friese, 1900, pp. 244, 333.

elegans Smith, 1874, p. 372. ♀. ST. VINCENT.

Ashmead, 1900, p. 300. Grenada, W. I. Probably var. *grenadensis*.

Centris (Cyanocentris) elegans Friese, 1900, pp. 244, 332. On p. 350 he proposes n. n. *gracilis* because he included *Epicharis* in *Centris*, thereby introducing *E. elegans* Smith, 1861.

Centris (Hemisia) elegans Cockerell, 1906, p. 98.

Cockerell, 1919, p. 186. ♂; windward side of ST. VINCENT, W. I.; (H. H. Smith).

elegans grenadensis Cockerell, 1919, p. 186. ♂. GRENADA; (H. H. Smith).

errans. See *versicolor*.

fascialis. See *nitida fascialis*.

fasciata Smith, 1854, p. 377. ♀, ♂. JAMAICA.

Fox, 1891, p. 348. Kingston, JAMAICA.

Centris (Pacilocentris) fasciatella Friese, 1900, pp. 244, 332. N. n. given because he joined *Epicharis* with *Centris*, thereby introducing *fasciata* Lepeletier, 1825. MEXICO.

Centris (Pacilocentris) fasciata Schrottky, 1902, p. 325. Lagoa Santa, Minas Gerais, BRAZIL.

Hemisia fasciata Schrottky, 1905, p. 13.

See *versicolor*.

fasciatella. See *fasciata*.

flavifrons Fabricius, 1775, p. 383. (*Apis*) ♀. BRAZIL.

Anthophora flavifrons Fabricius, 1804, p. 375.

Lepeletier, 1841, p. 152.

Smith, 1854, p. 369. ♂.

Centris citrotæniata Gribodo, 1893, p. 268. ♀; Chiriqui, PANAMA.

Fox, 1895, p. 272. Tepic, MEXICO.

Centris (Cyanocentris) flavifrons Friese, 1900, pp. 243, 317. States (p. 319) that he has specimens from Chiriqui, labeled *citrotæniata* by Gribodo, which are *flavifrons*, but he did not sink Gribodo's name.

Centris (Hemisia) citrotæniata Cockerell, 1906, p. 98.

Centris (Hemisia) flavifrons Cockerell, 1906, p. 98. MEXICO.

C. citrotæniata Cockerell, 1919, p. 192. Rio Mato, Caura district, VENEZUELA. BRITISH GUIANA; IV.

flavifrons flavofasciata Friese, 1899, p. 46. ♂. MEXICO.

flavifrons rufescens Friese, 1899, p. 46. ♂. Chiriqui, PANAMA.

flavofasciata. See *flavifrons flavofasciata*.

foxi. See *atripes*.

friesei. See *costaricensis*.

fuscata. See *bimaculata*.

fulviventris. See *lanipes*.

fusciventris scutellata Friese, 1900, p. 273. (*Centris Melanocentris*)

♂, ♀. Chiriqui, PANAMA.

gracilis. See *elegans*.

grenadensis. See *elegans grenadensis*.

gualanensis. See *inermis gualanensis*.

hæmorrhoidalis Fabricius, 1775, p. 386. (*Apis*) ♀. America.

Centris tabaniformis Fabricius, 1804, p. 358. ♂; SOUTH AMERICA.

Fabricius, 1804, p. 359. ♀. American islands.

Megilla hæmorrhoidalis Illiger, 1806, p. 142.

Hemisia tabaniformis Klug, 1807, p. 227.

Hemisia hæmorrhoidalis Klug, 1807, p. 227.

Anthophora hæmorrhoidalis Lamarck, 1817, p. 61.

Fox, 1891, p. 348. Kingston and Port Antonio, JAMAICA.

Ashmead, 1900, pp. 209, 300. GRENADA. CUBA. PORTO RICO. CENTRAL AMERICA. SOUTH AMERICA. Some of these are probably mistakes in identification.

Centris (Cyanocentris) hæmorrhoidalis Friese, 1900, pp. 243, 328. St. THOMAS. GUATEMALA.

Centris (Hemisia) hæmorrhoidalis Cockerell, 1906, pp. 73, 98. JAMAICA. Cockerell, 1912a, p. 140, made the specimens from Santo Domingo *lepetieri*.

Cockerell, 1919, p. 186. St. Andrew, JAMAICA; IV; (Taylor).

See *versicolor*.

hoffmanseggiae Cockerell, 1897, pp. 395, 397. ♂ (not ♀). College Farm Mesilla Valley, NEW MEXICO; V; at *Hoffmanseggia falcaria*. See *cockerelli*.

Cockerell, 1897a, p. 29. Juarez, MEXICO.

Centris lanosa Cockerell, 1897, p. 397, ♀ only, and not of Cresson.

Fox, 1899, p. 68. Gives the above synonymy.

Cockerell, 1900b, p. 243. At *Prosopis glandulosa*; V. See 1900, p. 363.

Centris (Melanocentris) hoffmanseggiae Friese, 1900, pp. 242, 295, 341.

Fowler, 1902, p. 317. Redlands, CALIFORNIA; VI; (Woodworth).

Centris (Ptilotopus) hoffmanseggia Cockerell, 1906, p. 97.

Cockerell, 1919, p. 187. Claremont, CALIFORNIA; (Baker).
See *cockerelli*.

hoffmanseggiae davidsoni Cockerell, 1904e (1905), p. 160. ♂. Banning, CALIFORNIA; (Davidson).

ignita Smith, 1874, p. 362. Orizaba, MEXICO.

Centris (Rhodocentris) ignita Friese, 1900, p. 243, 307.

Centris (Trachina) ignita Cockerell, 1906, p. 97.

See *agilis*.

inermis Friese, 1899, p. 46. ♀, ♂. Orizaba, MEXICO. BRAZIL.

Centris (Rhodocentris) inermis Friese, 1900, pp. 243, 314. PANAMA. PERU. Bogota, COLOMBIA.

Centris (Trachina) inermis Cockerell, 1906, p. 97.

See *versicolor*.

inermis gualanensis, Cockerell, 1912a, p. 568. ♀, ♂. Gualan* and Quirigua, GUATEMALA; II; (W. P. Cockerell).

insularis Smith, 1874, p. 367. ♀. SANTO DOMINGO.

Centris (Cyanocentris) insularis Friese, 1900, pp. 243, 326. São Paulo, BRAZIL; III and X; suggests that it is merely a variety of *versicolor*.

Centris (Hemisia) insularis Cockerell, 1906, p. 98.

Centris versicolor insularis Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

See *versicolor*.

labiata Friese, 1904, p. 91. ♂. San Carlos, COSTA RICA; (Burgdorf).

labrosa Friese, 1899, p. 44. ♀, ♂. Central and South America.

Centris (Rhodocentris) labrosa Friese, 1900, pp. 243, 302. HONDURAS. GUATEMALA. COLOMBIA. VENEZUELA. MEXICO. DUTCH GUIANA. FRENCH GUIANA. BRAZIL. At *Petraea volubilis*.

Centris (Rhodocentris) labrosa Schrottky, 1902, p. 323. Matto Grosso, BRAZIL.

Centris (Heterocentris) labrosa Cockerell, 1906, p. 97.

Centris labrosa Crawford, 1906, p. 159. Pozo Azul, COSTA RICA; VI.

See *lanipes* and *minuta*.

labrosa simplex Friese, 1899, p. 44. ♀. Central and South America.

Centris labrosa simplex Crawford, 1906, p. 159. Guacimo, COSTA RICA; 450 ft.; VI.

See *minuta*.

lanipes Fabricius, 1775, p. 386. (*Apis*) America.

Podalirius lanipes Latreille, 1802, p. 431.

Fabricius, 1804, p. 360. American islands.

Megilla lanipes Illiger, 1806, p. 141. ♀.

Lasius lanipes Jurine, 1807, p. 237. ♀, ♂.

Hemisia lanipes Klug, 1807, p. 227.

Lepeletier, 1841, p. 165. BRAZIL. May be *labrosa* Friese, according to Friese, 1900, p. 310; but Lepeletier's *picea*, p. 166, may be *lanipes*, and *trigonoides*, p. 167, not more than a variety of *lanipes*.

Centris fulviventris Cresson, 1865, p. 193. ♀. CUBA. *C. fulviventris* Mocsáry, 1896, p. 7, was named *rufohirta* by Friese, 1900, p. 299.

Centris dentipes Smith, 1874, p. 366. ♂. Ega, Santarem, Tapajos, and Pará, BRAZIL. WEST INDIES. MEXICO.

Centris vulpecula Burmeister, 1876, p. 164. ARGENTINA. His *lanipes*, p. 163, (not Fabricius) probably = *tricolor* Friese, 1899, p. 45.

Gribodo, 1891, p. 113. PATAGONIA. MONTEVIDEO. BRAZIL. ARGENTINA. VENEZUELA. MEXICO. GUADELUPE. ST. THOMAS.

Ashmead, 1900, p. 300. PORTO RICO.

Centris (*Rhodocentris*) *lanipes* Friese, 1900, pp. 243, 310, 313. Suggests that *tarsata* Smith may be a variety and that *fulviventris* is a synonym.

Schrottky, 1902, p. 324. Lagoa Santa, Minas Gerais, BRAZIL.

Schrottky, 1903, p. 578. At *Stachytarpha dichotoma* in BRAZIL.

Centris (*Trachina*) *lanipes* Cockerell, 1906, pp. 73, 97.

Crawford, 1906, p. 159. San José, COSTA RICA; 3550 ft.; VI.

Friese, 1906, p. 95. Mendoza, ARGENTINA; XII; (Jensen-Haarup). Also, p. 100, *C. tricolor*.

Centris vulpecula Cockerell, 1919, p. 190. Mendoza, ARGENTINA; (Reed). "I have this from Villa Encarnacion, PARAGUAY, sent by Schrottky as *C. lanipes* variety *tarsata* (Smith). This agrees with Friese's interpretation, but I do not think it is the true *tarsata*. Whether it should be considered a variety of *C. lanipes* I do not know; it is certainly closely allied."

See *tarsata*.

lanosa Cresson, 1872, p. 284. ♂. Bosque County; TEXAS, (Belfrage).

Fox, 1893, p. 22. MEXICO: San José del Cabo, (Eisen), Calmalli Mines, IV, and Calamujuet, V, (Haines), all in Lower California; and Hemrosillo, Sonora, IV, (Eisen). "Very likely identical with *C. mexicana* Sm."

Cockerell, 1897, p. 397. ♂ (not ♀). College Farm, Mesilla Valley, NEW MEXICO; V; at *Hoffmanseggia*. See *hoffmanseggia*.

Cockerell, 1900b, p. 243. At *Prosopis glandulosa*, V, and, 1901c, p. 42. *Parosela formosa*.

Centris (*Melanocentris*) *lanosa* Friese, 1900, pp. 242, 293, 342.

Centris (*Ptilotopus*) *lanosa* Cockerell, 1906, p. 97.

See *cockerelli*, *hoffmanseggia*, and *subhyalina*.

lepeletieri Cockerell, 1912a, p. 140. N. n. for *haemorrhoidalis* Lepeletier, 1841, p. 155. SANTO DOMINGO.

See *haemorrhoidalis*.

limbata Friese, 1899, p. 44. ♀. Fedor, TEXAS; IV; (Birkman).

Centris (*Melanocentris*) *limbata* Friese, 1900, pp. 242, 297.

Centris (*Ptilotopus*) *limbata* Cockerell, 1906, p. 97.

lunulata. See *Epicharis*.

lutea Friese, 1899, p. 43. ♂, ♀. VENEZUELA. BRAZIL. MEXICO.

Centris (Melanocentris) lutea Friese, 1900, pp. 242, 289.

Centris (Ptilotopus) lutea Cockerell, 1906, p. 97.

maculata (Smith) Friese, not Lepeletier. See *Epicharis (Epicharoides)*.

maculifrons Smith, 1854, p. 372. ♀. BRAZIL.

Centris (Cyanocentris) maculifrons Friese, 1900, pp. 244, 330.

Centris (Hemisia) maculifrons Cockerell, 1906, p. 98. MEXICO.

marginata. See *morsei marginata*.

melanchlæna Smith, 1874, p. 360. ♂. Vera Cruz, MEXICO.

Centris (Melanocentris) melanochlæna Friese, 1900, pp. 242, 270. VENEZUELA. BOLIVIA. Gives *nobilis* Friese, i. l., as synonym.

Centris (Ptilotopus) melanochlæna Cockerell, 1906, p. 97.

metatarsalis. See *Epicharis*.

mexicana Smith, 1854, p. 378. ♀. MEXICO.

Centris (Melanocentris) mexicana Friese, 1900, pp. 242, 289. ♀, ♂. Orizaba, MEXICO.

Centris (Ptilotopus) mexicana Cockerell, 1906, pp. 73, 97. Cuernavaca, MEXICO.

See *lanosa*.

mexicana albiceps Friese, 1899, p. 43. ♂. MEXICO.

minuta Mocsáry, 1899, p. 254. ♂. MEXICO. São Paulo, BRAZIL.

Centris (Melanocentris) minuta Friese, 1900, pp. 242, 293, 303. VENEZUELA. Yucatan, MEXICO. At *Petraea volubilis* and *Ipomæa*. Says that, according to Dücke, it is the ♂ of *labrosa*.

Friese, 1908, p. 40. TRINIDAD.

mocsáryi Friese, 1899, p. 42. ♀, ♂. Minas Geraës, São Paulo and Pará, BRAZIL. VENEZUELA. PERU. MEXICO.

Centris (Melanocentris) mocsáryi Friese, 1900, pp. 242, 274.

Centris (Ptilotopus) mocsáryi Cockerell, 1906, p. 97.

monozona. See *Epicharis*.

montezuma Cresson, 1879, p. 213. ♀, ♂. MEXICO; (Sumichrast).

Centris (Rhodocentris) montezuma Friese, 1900, pp. 243, 308.

Centris (Trachina) montezuma Cockerell, 1906, pp. 73, 97.

morsei Cockerell, 1897a, p. 355. ♂. Mesilla, NEW MEXICO; VI; (A. P. Morse). Cockerell, 1897c, p. 29; no description.

Centris (Pæcilocentris) morsei Friese, 1900, pp. 244, 335. TEXAS.

Centris (Ptilotopus) morsei Cockerell, 1906, p. 97.

Hemisia morsei Bequaert, 1918, p. 126. Sierra Blanco, TEXAS; at *Centaurea*.

morsei marginata Fox, 1899, p. 67. (*C. marginata*) ♂. Las Cruces, NEW MEXICO; VIII; at *Cevallia sinuata*.

Centris (Ptilotopus) marginata Cockerell, 1906, p. 97.

Cockerell, 1906a, p. 72. San Bernadino Ranch, Douglas, ARIZONA; 3750 ft.; VIII; (Snow).

mustelina. See *Xenoglossa*.

nigrescens. See *nitens*.

nigriventris. See *nitida*.

nigrocærulea Smith, 1874, p. 369. ♀, ♂. MEXICO.

Centris (Cyanocentris) nigrocærulea Friese, 1900, pp. 243, 329.

Centris (Hemisia) nigrocærulea Cockerell, 1906, p. 98.

nitens Lepeletier, 1841, p. 163. ♀. BRAZIL.

Centris nigrescens Burmeister, 1876, p. 163. ♂, ♀; Lagoa Santa, BRAZIL.

Centris (Cyanocentris) nitens Friese, 1900, pp. 244, 330. Jundiaby and São Paulo, X, (Schrottky), and Minas Geraes and Yponema, BRAZIL. MEXICO. (Briart).

nitida Smith, 1874, p. 368. ♀. HONDURAS.

(?) *Centris nigriventris* Burmeister, 1876, p. 165. ♀, ♂. Mendoza and Buenos Ayres, ARGENTINA.

Centris (Melanocentris) nitida Friese, 1900, pp. 242, 290. ♀, ♂. VENEZUELA. COLOMBIA. Orizaba, MEXICO. V. These records probably include *otomila*, as well as *nigriventris*.

Centris (Ptilotopus) nitida Cockerell, 1906, p. 97.

Crawford, 1906, p. 158. San José, COSTA RICA; V, VI.

See *transversa*.

nitida fascialis Mocsáry, 1899, p. 253. (*C. fascialis*) ♀. Songo and S. Antonio, BOLIVA.

Centris fascialis Friese, 1900, p. 292. COLOMBIA. Bahia, BRAZIL.

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

nobilis. See *melanchlæna*.

obsoleta Lepeletier, 1841, p. 153. ♀. FRENCH GUIANA.

Smith, 1854, p. 377. ♂; Rio Tapajos, Amazonas, BRAZIL.

Centris (Melanocentris) obsoleta Friese, 1900, p. 272. Pará, BRAZIL. Caracas, FRENCH GUIANA. VENEZUELA. HONDURAS.

obscuriventris Friese, 1900, p. 326. (*C. Cyanocentris*) ♂ (?), ♀; not definite as to locality. See *decolorata*.

Cockerell, 1919, p. 187. ♀. Bocas del Toro, PANAMA; VII; (Robinson).

Frontera, Tabasco, MEXICO.

Cockerell, 1920, p. 113. Maroni, FRENCH GUIANA.

otomita Cresson, 1879, p. 214. ♂. MEXICO; (Sumichrast).

Centris (Melanocentris) otomita Friese, 1900, pp. 242, 291. Suggests that it may be *nitida*.

Centris (Ptilotopus) otomita Cockerell, 1906, p. 97.

See *nitida*.

pallida Fox, 1899, pp. 63, 66. ♀. Phoenix, ARIZONA; V; at *Parkinsonia torreyana*; (Griffith).

Centris (Ptilotopus) pallida Cockerell, 1906, pp. 97, 314. "Lower Sonoran."

pandora. See *zonata*.

personata Smith, 1874, p. 362. ♂. Tapajos and Ega, BRAZIL.

Centris (Rhodocentris) personata Friese, 1900, p. 304. BOLIVIA. BRAZIL. DUTCH GUIANA. FRENCH GUIANA. COLOMBIA. MEXICO.

Cockerell, 1919, p. 191. Pará, BRAZIL. Aroa, VENEZUELA. Trinidad River, PANAMA; V.

picea. See *lanipes*.

pæcila Lepeletier, 1841, p. 154. ♀. CUBA.

Gribodo, 1893, p. 267. ♂. GUATEMALA. Chiriqui, PANAMA.

Centris (Cyanocentris) pæcila Friese, 1900, pp. 243, 328. Cordilleran region (Orizaba), MEXICO.

Centris (Hemisia) pæcila Cockerell, 1906, p. 98.

Cockerell, 1919, p. 190. Livingston, GUATEMALA; (Barber and Schwarz). Tamos, MEXICO; (Bishopp).

See *versicolor*.

pæcila segregata Crawford, 1906, p. 159. ♀. San José, COSTA RICA; 3550 ft., V, VI.

proxima Friese, 1899, p. 45. ♀, ♂. São Leopoldina, Jundiáhy, and Pará, BRAZIL.

Centris (Rhodocentris) proxima Friese, 1900, pp. 243, 307.

Centris (Trachina) proxima Cockerell, 1906, p. 98.

Crawford, 1906, p. 159. Guapiles, COSTA RICA; 1000 ft.; III.

Cockerell, 1919, p. 190. Escuintla, GUATEMALA; (Deam). Alhajuelo, PANAMA; (Busck).

pulchrrior. See *rhodopus pulchrrior*.

rhodopus Cockerell, 1897, p. 395. (*C. cæsalpinix* var. *rhodopus*) ♀, ♂. Mesilla Valley, NEW MEXICO; V; at *Hoffmanseggia falcaria*.

Cockerell, 1897c, p. 29. 1900b, p. 243; at *Prosopis glandulosa*; V.

Centris (Melanocentris) rhodopus Friese, 1900, pp. 242, 297.

Centris (Ptilotopus) rhodopus Cockerell, 1906, p. 97.

Viereck, 1906, p. 238. Bill Williams Fork, ARIZONA; VIII; (Snow).

Hemisia rhodopus Bequaert, 1918, p. 126. Sierra Blanco, TEXAS; at *Centaurea*.

rhodopus pulchrrior Cockerell, 1900, p. 363. ♂. Mesilla Park, NEW MEXICO; VI. Described, without a name, by Fox, 1899, p. 68.

rubripes. See *atriventris rubripes*.

rufescens. See *flavirifrons rufescens*.

schwarzi Cockerell, 1919, p. 192. ♀. Cacao, Alta Vera Paz, GUATEMALA; III; (Barber and Schwarz).

scutellata. See *fusciventris scutellata*.

segregata. See *pæcila segregata*.

sericea Friese, 1899, p. 41. ♀. MEXICO; (Ehrenberg).

Centris (Melanocentris) sericea Friese, 1900, pp. 242, 271.

Centris (Ptilotopus) sericea Cockerell, 1906, p. 97.

simillima Smith, 1874, p. 370. ♀. SANTO DOMINGO.

Centris (Rhodocentris) simillima Friese, 1900, pp. 243, 316.

Centris (Trachina) simillima Cockerell, 1906, p. 98.

simplex. See *labrosa simplex*.

smithii Cresson, 1879, p. 229. N. n. for *Centris apicalis* Smith (not Guérin), 1874, p. 367. ♀. ST. BARTHOLOMEW. *C. smithii* Friese, 1899, p. 43, is a homonym = *bicolorella*. Cockerell, 1904, p. 235, = (?) *chilensis* Spinola.

Centris apicalis Ashmead, 1900, pp. 209, 300. ST. VINCENT.

Centris (Cyanocentris) apicalis Friese, 1900, pp. 243, 327. VENEZUELA. Chiriqui, PANAMA. ST. THOMAS. HAYTI.

Centris (Hemisia) smithii Cockerell, 1906, p. 98.

subhyalina Fox, 1899, p. 96. ♀. TEXAS. "May subsequently prove to be the female of *C. lanosa* Cress."

Centris (Ptilotopus) subhyalina Cockerell, 1906, p. 97.

tabaniformis. See *hæmorrhoidalis*.

tarsata Smith, 1874, p. 371. ♂. Santarem, BRAZIL.

Centris (Rhodocentris) tarsata Friese, 1900, pp. 243, 313. Suggests that it is a variety of *lanipes*.

Centris (Rhodocentris) tarsata Schrottky, 1902, p. 324. Mendoza, ARGENTINA. Banda Oriental, URUGUAY.

W. P. Cockerell, 1912, p. 279. Gualan, GUATEMALA; at *Iresine paniculata*. Cockerell, 1913a, p. 192. Quirigua, GUATEMALA; (W. P. Cockerell).

See *lanipes*.

testacea Lepeletier, 1841, p. 165. ♀. Habitat unknown.

Smith, 1874, p. 365. SANTO DOMINGO.

Centris (Rhodocentris) testacea Friese, 1900, pp. 243, 310. Port au Prince, HAYTI.

Centris (Trachina) testacea Cockerell, 1906, p. 98.

thoracica. See *domingensis*.

totonaca Cresson, 1899, p. 213. ♀. MEXICO; (Sumichrast).

Centris (Rhodocentris) totonaca Friese, 1900, pp. 243, 313.

Centris (Trachina) totonaca Cockerell, 1906, pp. 73, 98.

W. P. Cockerell, 1912, p. 281. Gualan, GUATEMALA.

transversa Pérez, 1905, p. 39. ♀, ♂. Tehuacan, MEXICO; (Digue).

Du Buysson (*in litt.*) considers this to be *nitida* Smith.

tricolor. See *lanipes*.

trigonoides. See *lanipes*.

varia Erichson, 1848, p. 591. (*Hemisia*) ♀. BRITISH GUIANA.

Dalla Torre, 1896, p. 09.

Centris (Cyanocentris) varia Friese, 1900, p. 327. BRAZIL. PERU. Chiriqui, PANAMA.

See *versicolor*.

versicolor Fabricius, 1775, p. 386. (*Apis*) America.

Podalirius versicolor Latreille, 1802, p. 431.

Fabricius, 1804, p. 359. Islands of America.

Megilla versicolor Illiger, 1806, p. 142. West Indies.

Lasius versicolor Jurine, 1807, p. 237.

Hemisia versicolor Klug, 1807, pp. 213, 215, 227.

Anthophora versicolor Lamarck, 1817, p. 62.

Centris versicolor (♀) and *decolorata* (♂) Lepeletier, 1841, pp. 154, 106.

GUADELOUPE.

Anthophora versicolor Lucas, 1856, p. 780. Havana, CUBA.

Centris versicolor and *decolorata* Smith, 1874, p. 364. Vera Cruz and Oaxaca, MEXICO. BRAZIL. SANTO DOMINGO.

Centris errans Fox, 1899, p. 65. ♀. Biscayne Bay, FLORIDA.

Ashmead, 1900, pp. 209, 300. GRENADA. ST. VINCENT. PORTO RICO. Some of these may be mistaken identifications.

Centris (Cyanocentris) versicolor, Friese, 1900, pp. 243, 325. Suggests that *insularis*, *varia*, *inermis*, *fasciata*, *pæcila*, and *hæmorrhoidalis* are merely color-forms of *versicolor*.

Holmberg, 1903, p. 431. ARGENTINA.

Schrottky, 1903, p. 577. At *Crotalaria paulina* in BRAZIL.

Centris (Hemisia) versicolor Cockerell, 1906, p. 98. JAMAICA; at *Crotalaria*.

Crawford, 1914, p. 131. DOMINICA; (Foote).

versicolor apicalis Guérin, 1845, p. 455. (*Anthophora*) ♀. CUBA.

Centris (Hemisia) versicolor apicalis Cockerell, 1906, p. 98.

versicolor insularis. See *insularis*.

vidua Mocsáry, 1899, p. 252. ♂. San Pedro Sula, HONDURAS.

Centris (Melanocentris) vidua Friese, 1900, pp. 242, 271. Orizaba, MEXICO. THAMM, PERU.

vittata. See *breviceps*.

vs pecula. See *lanipes*.

xylocopoides Fox, 1899, p. 70. ♀. TRINIDAD; XI.

Centris atra Friese, 1899, pp. 41, 118. ♀, ♂. Blumenau, BRAZIL. COLOMBIA. VENEZUELA. Possibly a prior name.

Centris (Melanocentris) atra Friese, 1900, pp. 241, 267, 344.

Ashmead, 1900, pp. 209, 300. GRENADA.

Centris (Ptilotopus) xylocopoides Cockerell, 1906, p. 97.

C. atra Cockerell, 1919, p. 192. Rio Mato, Caura district, VENEZUELA; (Carriker).

zonata Mocsáry, 1899, p. 251. ♀. Chiriqui, PANAMA.

Centris (Melanocentris) zonata Friese, 1900, pp. 241, 269. *C. pandora*, new name, was proposed (p. 350) because he included *Epicharis* with *Centris*, introducing *zonata* Smith.

CHALEPOGENUS Holmberg, 1903, p. 416(Type: *Chalepogenus incertus* Holmberg)*Desmotetrapedia* Schrottky, 1909, p. 223, has the same type, *muelleri* Friese = *incertus* Holmberg. See Cockerell, 1914c, p. 320.**calcaratus** Cresson, 1878, p. 136. (*Tetrapedia*) ♀, ♂. MEXICO: (Sumichrast).*Tetrapedia calcarata* Friese, 1899a, p. 296. COLOMBIA. VENEZUELA.*Tetrapedia calcarata* Cockerell, 1912b, p. 31. Quirigua, GUATEMALA; II; at *Pontederia cordata*; (W. P. Cockerell).

Cockerell, 1914c, p. 320.

Cockerell, 1917b, p. 302. Sonsonate, SALVADOR; VIII; (Knab). Paraiso, Canal Zone, PANAMA; I; (Busck).

Tetrapedia calcarata Cockerell, 1919, p. 211. St. Lucrecia, Vera Cruz, MEXICO; (Knab).**globulosus** Friese, 1899a, p. 298. (*Tetrapedia*) ♂. Locality unknown.

Cockerell, 1917b, p. 302. Tobago Island, PANAMA; VII; (Busck). ♀. Paraiso, Canal Zone, PANAMA; V; (Jennings).

mayarum Cockerell, 1912b, p. 30. (*Tetrapedia*) ♀, ♂. Quirigua, GUATEMALA; II; (W. P. Cockerell).

Cockerell, 1914c, p. 320.

moestus Cresson, 1878, p. 135. (*Tetrapedia*) ♀*, ♂. MEXICO: (Sumichrast).*Tetrapedia maesta* Friese, 1899a, p. 288. GUATEMALA. See *Tetrapedia atripes*.*Tetrapedia maesta* Cockerell, 1912b, p. 31. Quirigua, GUATEMALA; II; at *Pontederia cordata*; (W. P. Cockerell).

Cockerell, 1914c, p. 320.

Cyanocentris FrieseSee *Centris*.*Desmotetrapedia* SchrottkySee *Chalepogenus*.*Diadasiella* AshmeadSee *Exomalopsis*.*Epeicharis* RadoszkowskySee *Tetrapedia*.**EPICCHARIS** Klug, 1807, pp. 211-214, 226.(Type: *Centris umbraculata* Fabricius)Friese, 1900, brings together the original descriptions of all the species, gives keys, etc., making it a subgenus of his *Centris*.

Epicharoides Radoszkowsky, 1884, p. 20, (Type: *bipunctatus* Rad.) is here considered as a subgenus, our only species being *maculata*.

Eucharis Lepeletier, 1825, p. 794.

albofasciata. See *maculata*.

bicolor Smith, 1854. ♂. BRAZIL.

Centris (Epicharis) bicolor Friese, 1900, p. 260. ♀, ♂. Pernambuco and São Paulo, BRAZIL. Montevideo, URUGUAY. FRENCH GUIANA. MEXICO. *C. flaviventris*, new name, was proposed (p. 350) because he included this species in the same genus as *Centris bicolor* Lepeletier.

bipunctatus. See *maculata*.

conura Cockerell, 1917, p. 200. ♀. San Carlos, COSTA RICA; (Schild and Burgdorf).

elegans Smith, 1861, p. 152. ♀, ♂. MEXICO; (Sallé).

Centris (Epicharis) elegans Friese, 1900, p. 260. Oaxaca, MEXICO.

flaviventris. See *bicolor*.

lunulata Mocsáry, 1898, p. 499. ♀, ♂. Chiriqui, PANAMA. Praesidio, MEXICO.

Centris (Epicharis) lunulata Friese, 1900, p. 261. Orizaba, MEXICO.

maculata Smith, 1874, p. 320. ♀. Oaxaca, MEXICO.

Epicharis albofasciata Smith, 1874, p. 321. ♂. São Paulo, Pará, BRAZIL. •

Epicharoides bipunctatus Radoszkowski, 1884, p. 20. MEXICO.

Friese, 1899, p. 39. Montevideo, URUGUAY. BRAZIL. VENEZUELA.

Centris (Epicharis) maculata Friese, 1900, p. 262. *C. variabilis*, new name, was proposed (p. 350) because he included this species in the same genus as *Centris maculata* Lepeletier.

Ducke, 1910, p. 365, says that Friese's *maculata* is *albofasciata* Smith, not *maculata* Smith, and that the latter is a Mexican species allied to *cockerelli*.

Cockerell, 1919, p. 194. FRENCH GUIANA; (Schaus). Rio Mato, Caura district, VENEZUELA; (Carriker).

metatarsalis Friese, 1899, p. 40. ♂. St. Parime, VENEZUELA. COLOMBIA.

Centris (Epicharis) metatarsalis Friese, 1900, p. 264.

Centris (Epicharis) metatarsalis Friese, 1904, p. 90. ♀, ♂. San Carlos, COSTA RICA; (Burgdorf).

monozona Mocsáry, 1898, p. 498. ♀. PANAMA.

Centris (Epicharis) monozona Friese, 1900, p. 259. Bogota, COLOMBIA.

Cockerell, 1906, p. 98. MEXICO.

phenacura Cockerell, 1917, p. 200. ♂. San Carlos, COSTA RICA; (Schild and Burgdorf).

variabilis. See *maculata*.

Epichoroides Radoszkowsky

See *Epicharis*.

Eucharis Lepeletier

See *Epicharis*.

EXOMALOPSIS Spinola, 1851, p. 89

(Type: *Exomalopsis aureopilosa* Spinola)

Taschenberg, 1883, p. 82, designated *fulvopilosa* Spinola as the type but it is now considered to be a synonym of *aureopilosa*.

Friese, 1899a, pp. 250-270, gives a summary of previous work. Cockerell, 1905a, p. 10, gives a key to U. S. species and, 1918a, p. 476, to certain other species.

Anthophorula Cockerell, 1897c, p. 44 (Type: *compactula* Ckll.) is here considered as a subgenus. See also Cockerell, 1898, p. 452, and 1898a, p. 70; also Friese, 1899a, p. 247.

Diadasiella Ashmead, 1899, p. 64 (Type: *coquilletti* Ashmead). See Cockerell and Porter, 1899, p. 406.

albovittata Cockerell, 1918a, p. 477. ♀. Oaxaca, MEXICO; (Crawford).

bruneri Crawford, 1902, p. 238. ♀, ♂. Lincoln, NEBRASKA; at *Helianthus annuus*.

Anthophorula bruneri Cockerell, 1906, p. 98.

Anthophorula bruneri Cockerell, 1911, p. 390. Sterling, COLORADO; VIII; at *Helianthus lenticularis*.

Anthophorula bruneri Cockerell, 1914, p. 114. Dallas, TEXAS; IX; at *Helianthus*; (Bishopp).

See *Melissodes pygmaea*.

callura Cockerell, 1912b, p. 319. ♂. Gualan, GUATEMALA; at *Vernonia aschenborniana*; (W. P. Cockerell).

chlorina Cockerell, 1918a, p. 477. ♀. Las Cruces, NEW MEXICO; VIII; at *Sphaeralcea*.

compactula Cockerell, 1897c, p. 44. (*Anthophorula*) ♀. Las Cruces, NEW MEXICO; VIII; at *Dithyræa wislizenii*; (Townsend).

Cockerell, 1898a, p. 70. Mesilla Valley, NEW MEXICO. See footnote; also, 1898, p. 451: ♀, ♂; La Cueva, Organ Mountains, NEW MEXICO; IX; at *Phacelia congesta*; (Townsend).

Anthophorula compactula Cockerell, 1906, pp. 98, 312. "Lower Sonoran."

Anthophorula compactula Cockerell, 1906a, p. 73. Brownsville, TEXAS; VI; (Snow).

coquilletti Ashmead, 1899, p. 64. (*Diadasiella*) ♂. This species was described by Ashmead, in his generic description of *Diadasiella*, but it is further described by Cockerell and Porter, 1899, p. 406, from the type specimen. San Diego County, CALIFORNIA.

Anthophorula coquilletti Cockerell, 1903b, p. 78, and 1905, pp. 14, 15. Los Angeles, CALIFORNIA.

Anthophorula coquilletti Cockerell, 1915c, p. 232. Claremont, CALIFORNIA; (Baker).

crucis Cockerell, 1918a, p. 478. Medellin, Vera Cruz, MEXICO; (Hyde). Also San Juan Allende, MEXICO; XI; (Townsend).

cubensis Spinola, 1851, p. 92. ♀. Cuba; (Poey). Insufficiently described.

eriocarpus. See *Xenoglossodes*.

frederici Cockerell, 1914, p. 115. ♂. MEXICO; (F. Smith).

fulvescens Smith, 1879, p. 127. ♀. Oaxaca, MEXICO.

Friese, 1899a, p. 255. ♂. Orizaba, MEXICO; (Krieger).

Cockerell, 1905e, p. 326. Note on type.

globosa Fabricius, 1793, p. 333. (*Apis*) ♀, ♂. West Indies; (Sehestedt).

Anthophora globosa Fabricius, 1804, p. 375.

Megilla (?) *globosa* Illiger, 1806, p. 142.

Friese, 1899a, p. 258. ST. THOMAS. PORTO RICO. COLOMBIA. Gives *obliqua* Friese, i. l., as a synonym and suggests that *pulchella*, *pubescens*, *penelope* and perhaps *similis* are merely color-varieties. The *pubescens* of Ashmead, 1900, from Grenada and St. Vincent probably belongs here.

Holland, 1917, p. 296. Nueva Gerona, Isle of Pines, CUBA; VIII, IX; (Link).

Cockerell, 1917b, p. 302. Mayaguez, PORTO RICO; I; (Hooker).

limata Cresson, 1878, p. 133. ♀. MEXICO; (Sumichrast).

Friese, 1899a, p. 256. Orizaba, MEXICO.

melanurus Cockerell, 1916d, p. 59. ♀. Claremont, CALIFORNIA; (Baker). "Not typical *Exomalopsis*."

mellipes Cresson, 1878, p. 134. (*Exomalopsis* ?) ♀. MEXICO; (Sumichrast).

Cockerell, 1904a, p. 24. San Rafael, Vera Cruz, MEXICO; at *Cordia*; (Townsend).

Cockerell, 1918a, p. 476. ♂. Medellin, Vera Cruz, MEXICO; (Hyde).

mexicana Cresson, 1878, p. 133. ♀. MEXICO; (Sumichrast).

morgani Cockerell, 1914, p. 114. (*Anthophorula*) ♀. Falfurrias, TEXAS; V; at *Helianthus*; (A. C. Morgan).

nitens Cockerell, 1915c, p. 231. ♀. Laguna, CALIFORNIA; (La Follette). *obliqua*. See *globosa*.

otomita Cresson, 1878, p. 133. ♀. MEXICO; (Sumichrast).

Friese, 1899a, p. 268. Orizaba, XI, and Cordoba, MEXICO.

Friese, 1916, p. 296. San Mateo, COSTA RICA; (Burgdorf).

penelope Cockerell, 1897*b*, p. 161. ♀, ♂. San Rafael, Vera Cruz, MEXICO; VII; at *Cardia*; (Townsend).

Cockerell, 1899*b*, p. 16. Lower part of Rio Nautla, MEXICO.

Friese, 1899*a*, p. 260. Orizaba, V, Tampico and Huastec, MEXICO. BRAZIL.

Schrottky, 1903, p. 531. Bogotá, COLOMBIA.

See *globosa* Fabr.

planiceps Smith, 1879, p. 125. ♀, ♂. "Amazons, Tunantins."

Friese, 1899*a*, p. 262. Santos, X, and Bahia, BRAZIL.

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

pubescens Cresson, 1865, p. 192. ♂. CUBA; (Gundlach).

(?) Fox, 1891, p. 347. Kingston, JAMAICA.

Cockerell, 1906, p. 98. "Var. in Jamaica."

Holland, 1917, p. 296. Nueva Gerona, Isle of Pines, CUBA; VIII, IX; (Link).

See *globosa*.

puchella Cresson, 1865, p. 191. ♀, ♂. CUBA.

Fox, 1891, p. 347. Kingston and Port Antonio, JAMAICA.

Fox, 1893, pp. 25, 120. San José del Cabo, Lower California, MEXICO; X; (Eisen).

Friese, 1899*a*, p. 259. Port au Prince, HAITI. PORTO RICO. Portland, JAMAICA; (Riley).

Cockerell, 1912*b*, p. 29. Quirigua, GUATEMALA; at *Zerxenia virgula*, (W. P. Cockerell).

Friese, 1916, p. 296. San José, COSTA RICA; (Schmidt).

Holland, 1917, p. 296. Nueva Gerona, Isle of Pines, CUBA; VII-IX; (Link).

See *zerxenia* and *globosa*.

pygmæa Cresson, 1872, p. 279. (*Melissodes*) ♀. TEXAS; (Belfrage).

Melissodes pygmæa Schwarz, 1896, pp. 24-26. San Diego, Duval County, Texas. Sleeping habits.

Cockerell, 1916*d*, p. 60, says that it is an *Exomalopsis*, possibly *bruneri*.

ruftarsis Smith, 1879, p. 126. ♀. JAMAICA.

Fox, 1891, p. 347. Port Antonio, JAMAICA.

Ashmead, 1900, p. 301. CUBA. GRENADA. ST. VINCENT.

Cockerell, 1905*e*, p. 326. Note on type.

serrata Friese, 1899*a*, p. 270. ♂. Orizaba, MEXICO.

Anthophorula serrata Cockerell, 1906, p. 99.

sidæ Cockerell, 1897*b*, p. 160. ♀, ♂. Mesilla, NEW MEXICO; VII; at *Sida hederacea*.

Anthophorula sidæ Cockerell, 1906, p. 99.

similis Cresson, 1865, p. 191. ♀. CUBA.

Ashmead, 1900, p. 301. PORTO RICO.

Crawford, 1906, p. 161. Guacimo (450 ft.; VI) and Guapiles (1090 ft.; III), COSTA RICA.

W. P. Cockerell, 1912, p. 281. Gualan, GUATEMALA; at *Cordia alba*.

Cockerell, 1913a, p. 192. Quirigua, GUATEMALA; II; (W. P. Cockerell).

Crawford, 1914, p. 131. DOMINICA; (Foote).

See *globosa*.

snowi Cockerell, 1906a, p. 73. ♂. Brownsville, TEXAS; VI; (Snow).

solani Cockerell, 1896, p. 25. ♀. Albuquerque, VIII, at *Solanum elaeagnifolium*, and Las Cruces, X, at *Flaveria*, *Verbesina encelioides* and *Bigelovia wrightii*, NEW MEXICO.

Cockerell, 1897c, p. 23. Mesilla Valley and Organ Mountains (Dripping Spring and Soledad Canyon), NEW MEXICO.

Friese, 1899a, p. 256. Mesilla, NEW MEXICO; VII; at *Sphaeralcea augustifolia* [probably *S. lobata*]; (Cockerell). San Antonio, TEXAS; VI.

Cockerell, 1903, p. 444. Mescalero, NEW MEXICO; X; at *Bigelovia graveolens glabrata*.

solidaginis Cockerell, 1898, p. 452. ♂. Las Cruces, NEW MEXICO; VIII; at *Solidago canadensis arizonica*; (Townsend).

Cockerell, 1905a, p. 10. La Cueva, Organ Mountains, NEW MEXICO; about 5300 ft.; IX; at *Lippia wrightii*; (Townsend).

Cockerell, 1907d, p. 539. Mesilla and Albuquerque (with only two submarginal cells in each wing), NEW MEXICO; VI.

stearnsi Cockerell, 1905, p. 101. (*Melissodes*) ♀. Los Angeles and Redondo, CALIFORNIA; (Davidson).

Cockerell, 1916d, p. 59.

tepaneca Cresson, 1878, p. 134. ♀. MEXICO; (Sumichrast).

texana Friese, 1899a, p. 264. ♀, ♂. Fedor, TEXAS; IX to XI; (Birkman).

Anthophorula texana Cockerell, 1906, p. 90.

thermalis Cockerell, 1918a, p. 478. ♀. Aguascalientes, MEXICO; XII; (Bishopp).

verbesinae Cockerell, 1904a, p. 21. ♀. Mesilla Park, NEW MEXICO; VI; at *Verbesina exauriculata*; (Rhodes).

Cockerell, 1905a, p. 10. Tempe, ARIZONA; X; at *Heterotheca*; (Cockerell).

velutinus Cockerell, 1916d, p. 58. ♀. Claremont, CALIFORNIA; (Baker). "Not a typical *Exomalopsis*."

vincentana Cockerell, 1917b, p. 302. ♀. ST. VINCENT; (H. H. Smith).

Cockerell, 1918a, p. 476. ♂. Windward side of ST. VINCENT; (H. H. Smith).

zexmenis Cockerell, 1912c, p. 447. ♀. Quirigua, GUATEMALA; at *Zexmania virgulata*; (W. P. Cockerell). Gives this name to *Eromalopsis pulchella* Cockerell, 1912b, p. 29.

Cockerell, 1917a, p. 191. Point Isabel, TEXAS; IV; (W. P. Cockerell).

Fiorentinia

See *Tetrapedia*.

Hemisia

See *Centris*.

Heterocentris

See *Centris*.

Melanocentris

See *Centris*.

Pæcilocentris

See *Centris*.

Ptilotopus

See *Centris*.

Rhodocentris

See *Centris*

TETRAPEDIA Klug, 1810, p. 33

(Type: *Tetrapedia diversipes* Klug)

Friese, 1899a, pp. 247-304, gives a summary of previous work.

Epeicharis Radoszkowski, 1884, p. 18 (*mexicanus*).

Fiorentinia Dalla Torre, 1896, p. 334. New name for *Epeicharis* Radoszkowsky.

abdominalis Cresson, 1878a, p. 182. ♀, ♂. MEXICO; (Sumichrast).

albilabris Friese, 1916, p. 335. ♂. San José, COSTA RICA; (Schmidt).

albipes Friese, 1916, p. 334. ♂, ♀. San Mateo, COSTA RICA; (Burgdorf). Popayan and Cali Cauca, COLOMBIA.

amplipennis. See *lugubris*.

antennata Friese, 1899a, p. 297. ♀, ♂. Orizaba and Cordoba, MEXICO; (Saussure).

apicalis Cresson, 1878, p. 136. ♀. MEXICO; (Sumichrast).

Friese, 1899a, p. 289. Orizaba, MEXICO.

atripes Smith, 1854, p. 366. ♀. MEXICO; (F. Smith).

Friese, 1899a, p. 302. Suggests it may be Cresson's *mæsta*. (See *Chalepogenus*.)

calcarata. See *Chalepogenus*.

fraterna Cresson, 1878a, p. 136. ♂. MEXICO; (Sumichrast).

fusciventris. See *mexicana fusciventris*.

globulosa. See *Chalepogenus*.

griseus. See *mexicana griseus*.

lugubris Cresson, 1878, p. 135. ♂. MEXICO; (Sumichrast).

Friese, 1899a, p. 292. ♀; MEXICO. ♂; St. Parime, VENEZUELA.

Ducke, 1910, p. 364, is of the opinion that this species is a synonym of *amplipennis*.

mæsta. See *Chalepogenus mæstus*.

maura Cresson, 1878, p. 134. ♀*, ♂. MEXICO; (Sumichrast).

Friese, 1899a, p. 284. GUATEMALA. Orizaba, MEXICO

mayarum. See *Chalepogenus*.

mexicana Radoszkowsky, 1884, p. 19. (*Epeicharis*) ♂. Orizaba, MEXICO

Tetrapedia saussurei Friese, 1899a, p. 301. GUATEMALA. See Cockerell, 1906, p. 98.

mexicana fusciventris Friese, 1899a, p. 301. (*E. saussurei fusciventris*) ♂. MEXICO; (Saussure).

Tetrapedia mexicana fusciventris Cockerell, 1906, p. 98.

mexicana griseus Friese, 1899a, p. 301. (*E. saussurei griseus*) ♂. MEXICO; (Saussure).

Tetrapedia mexicana griseus Cockerell, 1906, p. 98.

mæsta. See *Chalepogenus*.

saussurei. See *mexicana*.

swainsonæ Cockerell, 1909, p. 398. ♀: Bath*, ST. THOMAS; and JAMAICA; (Swainson). ♂: P. Cr. River, ST. THOMAS; and JAMAICA; VI.

terminalis Cresson, 1878, p. 136. ♀. MEXICO; (Sumichrast).

Trachina

See *Centris*.

Anthophorinæ

Amegilla

See *Anthophora*.

Ancyloscelis

See *Diadasia* and *Leptergatis*.

Anthemoëssa

See *Anthophora*.

Anthophora Latreille, 1803, p. 167(Type: *Apis retusa* Linnæus)

Dalla Torre, 1896, uses the name *Podalirius* except where we have indicated. Cockerell, 1906, p. 64 *et seq.*, gives keys and notes.

The following subgenera may be recognized.

Amegilla Friese, 1897*a*, pp. 5, 18, 26.

Anthemoessa Robertson, 1905, p. 372. Type: *Anthophora abrupta* Say.

Micranthophora Cockerell, 1906, p. 66. Type: *Anthophora curta* Provancher.

abrupta Say, 1837, p. 409. ♂. INDIANA.

Anthophora sponsa Smith, 1854, p. 339. ♀; U S.

Anthophora sponsa Walsh, 1868, p. 9, fig. 5. ALTON, ILLINOIS; describes rest.

Cresson 1869, p. 291. MASSACHUSETTS. WEST VIRGINIA.

Cresson, 1872, p. 283. Bosque County (?), TEXAS; (Belfrage).

Riley, 1877, p. 563, describes *Hornia* [Coleoptera] in cells of this species.

Cresson, 1879, p. 227. CANADA.

Robertson, 1891*a*, pp. 576, 580, 591. At *Asclepias purpureascens*, *Hydrophyllum virginicum*, *Mertensia virginica*, *Convolvulus sepium*, and *Pentstemon pubescens* and *lavigatus digitalis*.

Robertson, 1894, p. 442. Macoupin County, ILLINOIS; at *Rosa humilis* and *setigera*.

Robertson, 1896, p. 169. Carlinville, ILLINOIS; VI; at *Gillenia stipulacea*.

Cockerell, 1899*c*, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

Cockerell, 1905*c*, p. 267. Fedor, Lee County, TEXAS; IV; (Birkman).

See Birkman, 1899, p. 245.

Anthemoessa abrupta Robertson, 1905, p. 372.

Tucker, 1909, p. 278. LAWRENCE, KANSAS; V, VI.

Smith, 1910, p. 694. Caldwell and Palisades, NEW JERSEY; VII.

Banks, 1912, p. 107. At *Ceanothus*.

A. (*Anthemoessa*) *abrupta* Viereck, 1916, p. 737.

abruptella Cockerell, 1906, pp. 69, 72. ♀. Los Angeles, CALIFORNIA; (Davidson).

affabilis Cresson, 1878*a*, p. 189. ♀, ♂. Bosque County, TEXAS; (Belfrage).

Podalirius affabilis Cockerell, 1897*e*, p. 105. Mesilla Park, NEW MEXICO; at plum blossoms.

Podalirius (Anthophora) affabilis Cockerell, 1898*a*, p. 69. Mesilla Valley, NEW MEXICO.

Cockerell, 1906, pp. 99, 311. Engle, NEW MEXICO. "Middle Sonoran." At *Astragalus* and *Lycium*.

alamosana Cockerell. See *urbana*.

albata Cresson, 1876, pp. 211, Pl. xxxv. ♀. Denver, COLORADO; VI; (Putnam).

A. (Micranthophora) albata Cockerell, 1906, p. 100.

albiceps. See *Emphoropsis*.

anstrutheri Cockerell, 1906, pp. 66, 71, 100. ♀. Los Angeles, CALIFORNIA; (Davidson). "Possibly *flavocincta* ♀."

A. (Micranthophora) anstrutheri Cockerell, 1906, p. 100.

A. anstrutheri variety *a* Cockerell, 1916, p. 283. ♀. Mountains near Claremont, CALIFORNIA; (Baker).

Bray, 1917, p. 93. Claremont, CALIFORNIA; IV; at *Lo'us glaber*.

apicalis. See *Centris versicolor apicalis*.

arthuri Cockerell, 1906, pp. 67, 72, 100. ♀. Maybell, COLORADO; VIII; (S. A. Johnson).

A. (Micranthophora) arthuri Cockerell, 1906, p. 100.

atrata Cresson, 1865, p. 189. ♂. CUBA.

aurulentocaudata. See *Emphoropsis*.

badia Dours, 1869, p. 107. ♂. MEXICO.

bidentata Provancher, 1882, p. 234. (*Ceratina*) ♂. CANADA.

Provancher, 1883, p. 718. (Have not seen.)

Anthophora nudata Provancher, 1889 (?), p. 336.

bomboides Kirby, 1837, p. 271. ♂. "Lat. 65°," CANADA.

Cresson, 1869, p. 291. ♀, ♂. MASSACHUSETTS. CONNECTICUT. PENNSYLVANIA. WEST VIRGINIA.

Cresson, 1872, p. 283. Bosque County (?), TEXAS; (Belfrage).

Provancher, 1884, p. 691. (Have not seen.)

(?) Cockerell, 1893, p. 338. Custer County, COLORADO. See *bomboides neomexicana* Cockerell, 1906d, p. 419.

Evans, 1896, p. 13. Sudbury, ONTARIO.

Cockerell, 1897c, p. 20. Santa Fé, NEW MEXICO; 7000 ft.

Grænicher, 1911, p. 248. Solon Springs, Douglas County, WISCONSIN; VII; at *Apocynum* and *rosæmifolium*.

See *scutellaris*.

bomboides canadensis Cresson, 1869, p. 292. (*A. canadensis*) ♂. Ontario, CANADA; (J. Pettit).

Cresson, 1879, p. 227.

(?) Cockerell, 1900a, p. 409. Olympia, WASHINGTON; VI; (Kincaid).

bomboides neomexicana Cockerell, 1900a, p. 408. ♂, ♀. Las Vegas* and Beulah, NEW MEXICO; V, VI; at alfalfa and *Lycium vulgare*. (?) P. 409: Sioux County, NEBRASKA.

Cockerell, 1905d, p. 60. Fort Collins, Denver, and Parker, COLORADO; V; Johnson bred the meloid *Leonidia neomexicana* (Ckll.) from cells collected near Parker. Cockerell, 1906, p. 99, records it at *Lycium*; and, p. 311, adds Trout Spring, Santa Fé and Pecos, NEW MEXICO; "Canadian to Upper Sonoran."

A. neomexicana Cockerell, 1906d, pp. 419, 443. Florissant, Teller County, and (?) Wet Mountain Valley, Custer County, COLORADO; VI, VIII; at *Polemonium* and *Iris missouriensis*.

A. neomexicana Stevens, 1919, p. 210. Marmarth, NORTH DAKOTA.

See *scutellaris* Swenk.

bomboides willingi Cockerell, 1911, p. 34. ♂. Prince Albert, Saskatchewan, CANADA; VI; (Willing).

californica Cresson, 1869, p. 290. ♂. CALIFORNIA; (Osten Sacken).

Podalirius californicus Cockerell, 1898f, p. 314. Las Cruces, NEW MEXICO; at *Cevallia sinuata*.

(?) *A. (Amegilla) californica* Viereck, 1906, p. 237. Oak Creek Canyon, ARIZONA; VII, VIII; (F. H. Snow). See *tezana* and Cockerell, 1906, pp. 65, 66, and 99.

Cockerell, 1916b, p. 55. Coronado Islands, MEXICO; VIII; at *Hazardia berberidis*.

See *tezana*.

canadensis. See *bomboides canadensis*.

capistrata Cresson, 1878a, p. 187. ♂. Bosque County (?), TEXAS; (Belfrage).

Fox, 1893, p. 118. El Toste, Lower California, MEXICO; 3400 ft.; (Eisen).

carbonaria. See *infernalis*.

cardui. See *smithii*.

catalinae Cockerell, 1910, p. 297. ♀. Catalina Island, CALIFORNIA; VIII; (W. P. Cockerell).

centriformis Cresson, 1879, p. 212. ♂. NEVADA; (Morrison).

centriformis vierecki Cockerell, 1906, pp. 69, 311. ♂. Alamogordo, NEW MEXICO; V; (Viereck). "Middle Sonoran."

cineraria. See *Emphoropsis*.

citreostrigata Dours, 1869, p. 95. ♀. North America.

cleomis. See *marginata*.

corvicolor. See *infernalis*.

costaricensis Friese, 1916, p. 332. ♂, ♀. San Carlos, COSTA RICA; (Burgdorf).

crotchii, Cresson, 1878a, p. 192. ♂. CALIFORNIA; (Crotch).

Podalirius crotchii Cockerell, 1898b, p. 54. Pasco, WASHINGTON; V; (Kincaid).

Fowler, 1902, p. 320. Berkeley, CALIFORNIA; V.

Cockerell, 1904e (1915), p. 161. Banning, CALIFORNIA; (Davidson).

Cockerell, 1906b, p. 277. Yakima and N. Yakima, WASHINGTON; V; (Jenne).

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

curta Provancher, 1895, p. 173. ♀. Los Angeles, CALIFORNIA; (Coquillett).

Fowler, 1902, p. 319. Fresno, Tulare, and Anaheim, CALIFORNIA; V.
Cockerell, 1905a, p. 272. Alamosa, COLORADO; VIII; at *Cleome*; (Johnson).

A. (Micranthophora) curta Cockerell, 1906, pp. 66, 70, 100, 311. Antonito, COLORADO; VIII; (Ball). Santa Fé, Las Vegas, Embudo, and Mesilla Valley, NEW MEXICO. "Transition to Middle Sonoran."

Cockerell, 1907, p. 396. NEW MEXICO: Alamogordo, V, and Highrolls, VI, (Viereck); Las Cruces, V and VIII, at *Dilhyrea wislizeni* and *Wedelia incarnata*; and Mesilla Park, VIII and IX, at plum flowers and *Pectis papposa*. San Pedro, CALIFORNIA; VII. Juarez, MEXICO; V.

Cockerell, 1914a, p. 424. El Paso, TEXAS; XI; at yellow Composite; (Timberlake).

Bray, 1917, p. 93. Claremont, CALIFORNIA; IV; at *Lotus glaber*.

See *perilomæ* and *petrophila*.

domingensis Lepeletier "is given by Smith as from S. Domingo, but according to Dours it is really from Senegal" (Cockerell, 1906, p. 105).

doursii. See *tarsata*.

edwardsii Cresson, 1878a, p. 190. ♀, ♂. CALIFORNIA* and NEVADA; (H. Edwards).

Fowler, 1902, p. 320. Berkeley and Ocean View, CALIFORNIA; V-X.

Cockerell, 1906b, p. 277. Yakima and N. Yakima, WASHINGTON; IV, V; (Jenne).

Bray, 1917, p. 94. Claremont, CALIFORNIA; IV; at *Phacelia tanacetifolia*.

elefas. See *Emphoropsis*.

euops. See *simillima*.

exigua Cresson, 1879, p. 211. ♀. NEVADA; (Morrison).

Podalirius exigua Cockerell, 1897c, p. 29. Mesilla Valley, NEW MEXICO; 3800 ft.

Fowler, 1902, p. 319. Alhambra, VI, Fresno, X, CALIFORNIA.

A. (Micranthophora) exigua Cockerell, 1906, p. 100.

fedorica Cockerell, 1906, pp. 69, 70. ♂. Fedor, TEXAS; IV; (Birkman).

flavifrons. See *Centris*.

flavocincta Huard, 1897, p. 25. N. n. for *nigrocincta* Provancher, 1895, p. 172. ♂. Los Angeles, CALIFORNIA; (Coquillett).

A. maculifrons Cockerell, 1905, p. 15. See 1906, p. 71.

A. nigrocincta Fowler, 1902, p. 319. Los Angeles, CALIFORNIA.

A. (Micranthophora) flavocincta Cockerell, 1906, p. 100.

See *anstrutheri*.

flexipes Cresson, 1879, p. 211. ♀*, ♂. NEVADA; (Morrison).

Cockerell, 1905, p. 13. Strawberry Valley, southern CALIFORNIA; (Davidson).

A. (Micranthophora) flexipes Cockerell, 1906, pp. 66, 71, 100. Bear Valley, southern CALIFORNIA. 1906d, p. 443: Florissant, COLORADO; VII.

floridana. See *Emphoropsis*.

footei Crawford, 1914, p. 131. ♂, ♀. DOMINICA; (Foote).

forbesi Cockerell, 1907*a*, p. 354. ♀. Maricopa, ARIZONA; (Forbes).

1907*d*, p. 539; Prof. R. H. Forbes found a ♂ *Bombomelecta arizonica*

Cockerell in a cell of this species at Tuscon, ARIZONA; IV.

frontata Say, 1837, p. 409. ♂. LOUISIANA; (Barabino).

fulvifrons. See *Entechnia*.

fumipennis Swenk, 1909, p. 391. ♀. Cass County, NEBRASKA.

furcata. See *Clisodon terminalis*.

fuscipennis Smith, 1854, p. 338. ♀. North America; (Smith).

globosa. See *Exomalopsis*.

godofredi Sichel MS., Dours, 1869, p. 119. ♀, ♂. ST. VINCENT.

gohrmanæ Cockerell, 1903, p. 454. ♂. Las Vegas, NEW MEXICO; V;
at *Ribes longiflorum* but tongue too short to suck; (Anna Gohrman).

Cockerell, 1905, p. 30, and 1905*a*, p. 81. Los Angeles, CALIFORNIA;
(Davidson).

Cockerell, 1905*d*, p. 60. Denver, Montrose, and Grand Junction.
COLORADO; V.

hæmorrhoidalis. See *Centris*.

hilaris Smith, 1879, p. 123. ♀. SANTO DOMINGO.

histris Dours, 1869, p. 190. ♂. MEXICO.

holopyrrha. See *Xenoglossa fulva*.

ignava Cresson, 1879, p. 210. ♀, ♂. NEVADA; (Morrison).

See *pacifica* Cresson. Fowler, 1902, p. 320.

Viereck, *et al.*, 1906, p. 314. Corvallis, OREGON; V, VI; (Cordley).
CALIFORNIA.

Cockerell, 1906, p. 99. ? ♀ of *pacifica*.

Cockerell, 1906*b*, p. 277. N. Yakima, WASHINGTON; V; (Jenne).

Cockerell, 1914*d*, p. 365. Portola, CALIFORNIA; III; (Newcomer).

infernalis Dalla Torre, 1896, p. 273. (*Podalirius*) N. n. for *A. carbonaria*

Cresson, 1879, p. 210. ♀. NEVADA; (Morrison).

A. corvicolor Cockerell, 1905*a*, p. 81. ♀. Laurel Canyon, CALIFORNIA;
V; (Davidson). Cockerell, 1906, p. 65, gives the synonymy.

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

See *Emphoropsis tristissima*.

insularis. See *solitaria*.

interspersa. See *peritomæ interspersa*.

krugii Cresson, 1878*a*, p. 188. ♀, ♂. PORTO RICO; (Krug).

lesquerellæ Cockerell, 1897, p. 399. (*Podalirius*) ♂. Little Mountain
and College Farm, Mesilla Valley, NEW MEXICO; IV; at *Lesquerella*
fendleri and *Lycium*; (Jessie Casad).

Anthophora lesquerellae Cockerell, 1896, p. 197. ♂, ♀. Mesilla Valley, New Mexico; IV; at *Lycium* and cherry.

Cockerell, 1899d, p. 256. Dripping Springs, Organ Mountains, New Mexico; IV; at *Ungnadia speciosa*.

Cockerell, 1906, p. 311. "Middle Sonoran."

Cockerell, 1911a, p. 238. Albuquerque, New Mexico; at *Astragalus*; (J. R. Watson).

luteodimidiata Dours, 1869, p. 192. ♀. MEXICO.

maculifrons Cresson, 1879, p. 210. ♀*, ♂. NEVADA; (Morrison).

Fox, 1893, pp. 21, 118. San José de Cabo, Lower California, Mexico; VII, X; (Eisen).

Townsend, 1896, p. 111. Las Cruces, New Mexico.

Cockerell, 1898a, p. 69. Mesilla Valley, Santa Fé, and Embudo, New Mexico. 1898f, pp. 313 and 314; at *Biglavia* [*Chrysothamnus*] and *Helianthus annuus*.

Fowler, 1902, p. 319. Alhambra and Redlands, CALIFORNIA; VI.

Cockerell, 1901a, p. 131. Las Vegas, New Mexico; VII, VIII; at *Sphaeralcea lobata*, *Lycium vulgare*, *Grindelia squarrosa*, and *Verbena macdougalii*; (Porter, Mize).

Cockerell, 1901c, p. 42. Mesilla Park, New Mexico; IV; at *Prunus*.

A. (*Micranthophora*) *maculifrons* Cockerell, 1906, p. 100.

See *flavocincta* and *petrophila*.

marginata Smith, 1854, p. 339. ♀. MEXICO.

Dours, 1869, p. 150. ♂ (?); see Cockerell, 1906, p. 65.

Cresson, 1869, p. 290. Orizaba, MEXICO; (Sumichrast).

Podalirius cleomis Cockerell, 1896, p. 193. ♂. Santa Fé, New Mexico; VIII; at *Cleome serrulata*. At 7000 ft.

A. *cleomis* Cockerell, 1898a, p. 68.

A. (*Amegilla*) *cleomis* Cockerell, 1901a, p. 131. Las Vegas, New Mexico; VII, VIII; at *Sphaeralcea lobata*, *Sidalcea neomexicana*, *Lycium vulgare*, *Verbena macdougalii*, *Salvia lanceolata*, and *Cleome serrulata*. Rociada, New Mexico.

Cockerell, 1901c, p. 39. Las Cruces, New Mexico; VIII; at *Wedelia incarnata*; (Townsend).

A. *cleomis* Cockerell, 1904, p. 8. Pecos, New Mexico; VIII.

Cockerell, 1905e, p. 331. Notes on type.

A. (*Amegilla*) *cleomis* Viereck, 1906, p. 237. Oak Creek Canyon, ARIZONA; VII, VIII; (Snow).

Cockerell, 1906, pp. 65, 99, 311. At *Peritoma*. "Transition to Upper Sonoran."

Cockerell, 1912, p. 106. Guatemala City, GUATEMALA; XII; (Wheeler).

Cockerell, 1914a, p. 281. Rito de los Frijoles, MEXICO; VIII.

melanopyrrha. See *Emphoropsis*.

melfordi Cockerell, 1908, p. 323. Fossil in Miocene Shales, Station 13 B, Florissant, Colorado; (Smith). 1908d, p. 575. Figure.

mexicana Dours, 1869, p. 133. ♀, ♂. MEXICO.

miserabilis. See *Emphoropsis*.

modesta Smith is from St. Vincent, Cape Verde Is., not W. I. as in Ashmead, 1900.

montana Cresson, 1869, p. 290. ♀. COLORADO; (J. Ridings).

Townsend, 1896, p. 111. La Vega de San José, NEW MEXICO; VIII.

Podalirius montanus Cockerell, 1897c, p. 22. Mesilla Valley, NEW MEXICO.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

A. (*Amegilla*) *montana* Cockerell, 1901a, p. 131. Las Vegas, NEW MEXICO; VII; at *Lycium vulgare* and *Cleome serrulata*; (Porter, Winters, Garlick).

Cockerell, 1904, p. 8. Pecos, NEW MEXICO; at *Salvia lanceolata*.

Cockerell, 1905d, p. 60. ♂. Denver (VII), Fort Collins, Livermore, and near Horsetooth Mountain, COLORADO; at larkspur.

Cockerell, 1906, p. 311. Organ Mountains, NEW MEXICO. "Upper Sonoran."

morrisoni. See *Emphoropsis*.

mucida. See *Emphoropsis*.

nebracensis Swenk, 1909, p. 390. ♀. Warbonnet Canyon, Sioux County, NEBRASKA; VII; at *Monarda fistulosa*; (Carriker).

neomexicana. See *bomboides neomexicana*.

nigrocincta. See *flavocincta*.

nubiterræ. See *Clisodon terminalis*.

nudata. See *bidentata*.

occidentalis Cresson, 1869, p. 292. ♀*, ♂. COLORADO; (Ridings).

Putnam, 1876, p. 195. Spring Lake Villa, Utah County, UTAH.

Cresson, 1876, p. 210. Boulder, COLORADO; (Putnam).

Cresson, 1879, p. 227. TEXAS (? misprint for Utah).

Townsend, 1896, p. 111. La Vega de San José, NEW MEXICO; VIII.

Podalirius occidentalis Cockerell, 1897c, p. 20. Santa Fé, NEW MEXICO; 7000 ft.; (1898f, p. 79) sleeping in closed flowers of *Argemone platyceras*.

Podalirius occidentalis Cockerell, 1899, p. 156. Mescalero Indian Agency, Tularosa Creek, NEW MEXICO; VII; (C. M. Barber). *Melecta miranda* Fox, probably inquiline.

Tucker, 1909, p. 278. Colorado Springs, COLORADO; VIII.

Cockerell, 1900a, p. 408. Las Vegas, NEW MEXICO; VII; at *Cnicus ochrocentrus*, *Cleome serrulata*, and *Convolvulus sepium*; (W. Porter).

Johnson, 1903, p. 290. Nests; *Agencia architecta* builds in them.

Cockerell, 1906, pp. 68, 70, 99, 311. Maybell (VIII) and Parker, COLORADO; (S. A. Johnson). Pecos, NEW MEXICO. "Transition to Upper Sonoran." At *Carduus* and *Peritoma*.

Wellman, 1911, p. 17. Gove County, KANSAS; 2813 ft.; V; nest contained *Hornia gigantea*. See also Entomological News, XXII, p. 132; XXIII, p. 259; and XXV, p. 1.

Stevens, 1919, p. 210. Williston, NORTH DAKOTA.

pacifica Cresson, 1878a, p. 190. ♂. CALIFORNIA; (H. Edwards).

Fowler, 1902, p. 320. Berkeley, CALIFORNIA; I-V. Says *ignava* Cresson is a synonym.

Cockerell, 1906, pp. 68, 99. NEVADA.

Bray, 1917, p. 93. Mountains near Claremont, CALIFORNIA; IV; at *Lotus glaber*.

peritomæ Cockerell, 1905a, p. 272. (*A. curta peritomæ*) ♂. Alamosa, COLORADO; VIII; at *Cleome* (= *Peritoma*); (S. A. Johnson). Santa Fe, VIII, at *Peritoma serrulatum*, Mesilla, IX, at *Isocoma wrightii*, and Las Cruces, VIII, at *Solidago canadensis*, NEW MEXICO.

A. (Micranthophora) curta peritomæ Cockerell, 1906, pp. 100, 311. "Transition to Middle Sonoran."

Cockerell, 1907, p. 397. ♀. Las Cruces, IX, at *Helianthus annuus*, Pecos, VII, San Ignacio, IX, Embudo, IX, at *Chrysothamnus*, Rociada, VIII, and Santa Fé, VIII, at *Chrysopsis*, NEW MEXICO.

peritomæ interspersa Cockerell, 1907, p. 397. ♂. Alamosa*, COLORADO; VIII; at *Cleome* (= *Peritoma*); (S. A. Johnson); see Cockerell, 1905a, p. 272, *A. curta*. Rociada, VIII, at *Grindelia nuda*, Santa Fé, VII, and Las Cruces, VIII, at *Solidago canadensis*, NEW MEXICO.

peritomæ tinctula Cockerell, 1907, p. 397. ♀*: Rociada, NEW MEXICO; VIII; at *Grindelia nuda*. ♂: Santa Fé, NEW MEXICO; VIII; at *Peritoma serrulatum*. Las Vegas, NEW MEXICO; VII and VIII; at *Verbesina exauriculata* and *Grindelia nuda*.

pernigra Cresson, 1879, p. 210. ♀. NEVADA; (Morrison).

petrophila Cockerell, 1905, pp. 13, 15. (*A. curta petrophila*) ♀. Rock Creek, CALIFORNIA; (Davidson).

A. (Micranthophora) petrophila Cockerell, 1906, p. 100.

Cockerell, 1907, p. 395. ♀. Los Angeles, CALIFORNIA; (Davidson). ♂. Alamogordo, NEW MEXICO; V.

phenax Cockerell, 1898e, p. 146. (*Podalirius*) College Farm, Mesilla Park, NEW MEXICO; IV; at plum.

Podalirius phenax Cockerell, 1898a, p. 69. ♂, ♀. Mesilla Valley, NEW MEXICO; IV; (C. M. Barber).

A. (Micranthophora) phenax Cockerell, 1906, pp. 100, 311. "Middle Sonoran."

pluto Dours, 1869, p. 95. ♀. MEXICO.

Habropoda pluto Patton, 1879, p. 479.

portera Cockerell, 1900a, p. 407. ♂, ♀. Romeroville, NEW MEXICO; IV; at wild gooseberry; (W. Porter). Mojave Desert, CALIFORNIA; (Ehrhorn).

Cockerell, 1905*d*, p. 60. Golden and Montrose, COLORADO; V; (S. A. Johnson).

Cockerell, 1906, pp. 68, 70, 99, 311. Fort Collins, COLORADO; VI; at "yellow sweet clover"; (S. A. Johnson). Las Vegas and Engle, NEW MEXICO; at *Ribes*. "Upper Sonoran."

Cockerell, 1911*a*, p. 238. Albuquerque, NEW MEXICO; IV; at cherry blossoms; (J. R. Watson).

porterae semiflava Cockerell, 1905*f*, p. 183. ♂. Fort Collins, COLORADO; V; (Johnson).

porterae watsoni Cockerell, 1911*a*, p. 238. ♂. Albuquerque, NEW MEXICO; at *Phacelia corrugata*; (J. R. Watson).

pulsella Dours, 1869, p. 190. ♀. MEXICO.

pygmaea Dours, 1869, p. 151. ♂. MEXICO.

pyralitarsis Dours, 1869, p. 160. ♂. NEW YORK.

quinquefasciata Provancher, 1895, p. 172. ♂. Los Angeles, CALIFORNIA; (Coquillett).

Fowler, 1902, p. 319.

rufosonata Dours, 1869, pp. 49 and 112. ♂. MEXICO.

scutellaris Swenk, 1909, p. 391. ♀. Sioux County,* NEBRASKA; (L. Brunner). Warbonnet Canyon, Sioux County, NEBRASKA; VI; (J. C. Crawford). The type is the specimen referred to by Cockerell, 1900*a*, p. 409, as *bomboides* var.

semiflava. See *porterae semiflava*.

simillima Cresson, 1878*a*, p. 189. ♂. COLORADO; (Morrison).

A. euops Cockerell, 1903, p. 451. ♂. Placita, NEW MEXICO; V; at *Ribes longiflorum* and wild plum.

A. euops Cockerell, 1904, p. 234. Colorado Springs, at *Ribes longiflorum*, Manitou, IV, at *Ribes leptanthum*, and Colorado City, V, at *Thermopsis arenosa* and *Ribes longiflorum*, COLORADO.

Cockerell, 1904*a*, p. 24. Prospect Lake, Colorado Springs, COLORADO; V; at *Aragallus lamberti*.

Cockerell, 1905*d*, p. 60. Palisade, Fort Collins, and Denver, COLORADO; V.

Cockerell, 1906, pp. 68, 69, 99. Boulder, COLORADO; IV; at *Ribes cereum*, *Aragallus*, and *Viola nuttallii*. Nevada.

Cockerell, 1906*d*, p. 443. Florissant, Teller County, COLORADO; VI, VII; at *Pentstemon*.

Cockerell, 1906*b*, p. 277. N. Yakima, WASHINGTON; V; (Jenne).

Bray, 1917, p. 94. Claremont, CALIFORNIA; IV; at *Lotus glaber*.

Cockerell, 1919*d*, p. 358. Minnehaha, Pikes Peak, COLORADO; (Frances Long).

smithii Cresson, 1869, p. 289. ♂*, ♀. COLORADO*, (J. Ridings), and "Dacota Territory," (H. Ulke).

Cresson, 1872, p. 282. Bosque County (?), TEXAS; (Belfrage).

Cresson, 1879, p. 227. NEW MEXICO.

Anthophora walshii Townsend, 1896, p. 111. La Vega San José, NEW MEXICO; VIII.

Podalirius cardui Cockerell, 1897a, p. 155. ♂. About 6000 ft., Lone Mountain, near Silver City, NEW MEXICO; VII; at *Cnicus*.

Podalirius walshii Cockerell, 1897c, p. 22.

Anthophora cardui Cockerell, 1898a, p. 98.

Podalirius cardui Cockerell, 1899, p. 156. Mescalero Indian Agency, Tularosa Creek, NEW MEXICO; VII; (C. M. Barber).

Podalirius smithii Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Anthophora (Amegilla) cardui Cockerell, 1901a, p. 131. Las Vegas, NEW MEXICO; VII, VIII; at *Cleome serrulata*, *Petalostemon oligophyllus*, and *Verbena macdougalii*; (Porter).

A. smithii and *A. s. cardui* Cockerell, 1906, pp. 70, 99, 311. Top of Las Vegas Range, Beulah, and Las Vegas Hot Springs, NEW MEXICO. Denver, COLORADO; VII; (S. A. Johnson). "Hudsonian to Upper Sonoran." At *Carduus*.

Tucker, 1909, p. 278. Colorado Springs, COLORADO; VIII.

Cockerell, 1915, p. 268. Ward, COLORADO; 9200 ft.; VIII; at *Grindelia subalpina*.

Cockerell, 1919b, p. 293. Longs Peak Inn, COLORADO. Differences between *smithii* and the form *cardui*.

Cockerell, 1919c, p. 27, 272. Boulder, COLORADO; X; at *Salvia pitcheri*. Gold Hill, COLORADO; 8600 ft.; VII.

Cockerell, 1919d, p. 358. Minnehaha, Pikes Peak, COLORADO; (Frances Long).

sodalis Cresson, 1879, p. 212. ♂. NEVADA; (Morrison).

Cockerell, 1906b, p. 277. N. Yakima, WASHINGTON; V; (Jenne).

solitaria Ritsema, 1880, p. xcvi. New name for *insularis* Smith. ♀. Vancouver Island, BRITISH COLUMBIA.

Fowler, 1902, p. 320. Santa Catalina Island and San Bernardino, CALIFORNIA; VI.

(Not *solitaria* "Cockerell" as in Viereck *et al.*, 1905, p. 314. See Cockerell, 1906, p. 67.)

sponsa. See *abrupta*.

squammulosa Sichel MS., Dours, 1869, p. 78. ♀, ♂. MEXICO.

stanfordiana Cockerell, 1904c, p. 32. ♀, ♂. Stanford University, CALIFORNIA; V; (W. G. Johnson). Nests.

Viereck *et al.*, 1905, p. 314. Corvallis, OREGON; III, V, VI; (Cordley).

Kellogg, 1908, p. 516. Description of nest.

Bray, 1917, p. 93. Claremont, CALIFORNIA; V; at *Amsinckia intermedia*.

subglobulosa Provancher, 1888, p. 297. ♂. Cap Rouge, CANADA.

subtarsata. See *tarsata subtarsata*.

tarsata Sichel MS., Dours, 1869, p. 147. ♀, ♂. MEXICO.

Podalirius doursii Dalla Torre, 1896, p. 265.

tarsata subtarsata Cockerell, 1904e, p. 88. ♀, ♂. Los Angeles. CALIFORNIA; (Davidson).

Cockerell, 1905, p. 335.

taurea. See *Entechnia*.

terminalis. See *Clisodon*.

texana Cresson, 1872, p. 282. ♀. Bosque County (?); TEXAS; (Bel-frage).

Podalirius californicus Cockerell, 1897b, p. 154. ♂. DEMING, NEW MEXICO; VII; at *Casalpinia falcaria*. 1897c, p. 29: Mesilla Valley, NEW MEXICO; 3800 ft.; VIII; at *Cevallia*.

Cockerell, 1905c, p. 335. ♂. Fedor, TEXAS; VI; (Birkman. See Birkman, 1899, p. 245). ARIZONA; (Snow).

Cockerell, 1906, pp. 65, 66, 100, 311. At *Hoffmannseggia*. "Middle Sonoran."

Cockerell, 1919, p. 183. Federal District, MEXICO; (Inda).

trinctula. See *peritomæ tinctula*.

tricolor Fabricius, 1775, p. 377. (*Andrena*) America.

Megilla tricolor Fabricius, 1804, p. 329.

Lepelletier, 1825, p. 797.

Smith, 1854, p. 343. South America—doubtful.

Cresson, 1869, p. 292. "Guadaloupe." HAITI; (Uhler).

Gribodo, 1893, p. 391. ST. THOMAS.

Ashmead, 1900, p. 300. PORTO RICO. CENTRAL AMERICA.

unistrigata Dours, 1869, p. 192. ♀. MEXICO.

urbana Cresson, 1878a, p. 188. ♀*, ♂. UTAH*. COLORADO. CALIFORNIA.

Podalirius alamosanus Cockerell, 1896, p. 195. ♀. Canyada Alamosa, NEW MEXICO; VI; (Townsend).

Cockerell, 1897, p. 400. Las Cruces, NEW MEXICO; VII; at *Solanum*.

P. u. alamosana Cockerell, 1898a, pp. 69, 73. Albuquerque and western base of Organ Mountains, NEW MEXICO; IX; at *Cleome serrulata*. See also 1898f, p. 311.

A. (Amegilla) u. alamosana Cockerell, 1901a, p. 131. Las Vegas, NEW MEXICO; VI, VII; at alfalfa and *Lycium vulgare*; (Porter).

Cockerell, 1901, p. 297. San Pedro, CALIFORNIA; VII.

Fowler, 1902, p. 320. Fresno, Tulare, Santa Ana, and Berkeley, CALIFORNIA; V-X.

A. u. alamosana Cockerell, 1904, p. 234. Blue River, ARIZONA; (Davidson).

Cockerell, 1905, p. 31. Bear Valley, Tehachapi, Redondo (Davidson) and Los Angeles, CALIFORNIA. The second *A. urbana* on p. 31 should be *Synhalonia* [*Tetralonia*] *acerba* (Cresson).

Viereck, 1906, p. 237. Oak Creek Canyon, ARIZONA; VII, VIII; (Snow).

A. u. alamosana Cockerell, 1906, p. 100. At *Lycium*.

Cockerell, 1906, pp. 68, 70, 100, 311. Fort Collins, COLORADO; VI; on yellow sweet clover; (S. A. Johnson). NEVADA. "Upper Sonoran."

Cockerell, 1906b, p. 277. N. Yakima, WASHINGTON; VI; (Jenne).

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

Cockerell, 1916b, p. 55. Coronado Islands, MEXICO; VIII.

Bray, 1917, p. 93. Claremont, CALIFORNIA; IV; at cactus and poppy.

Cockerell, 1920, p. 113. Santa Fé, NEW MEXICO.

See *Tetralonia acerba*.

ursina Cresson, 1869, p. 291. ♂. WEST VIRGINIA; (Ridings).

Cresson, 1879, p. 227. NORTH CAROLINA.

Robertson, 1891a, pp. 580, 589. At *Mertensia virginica* and *Collinsia verna*.

Robertson, 1896, pp. 160, 162. Carlinville, ILLINOIS; at *Æsculus glabra* and *Astragalus mexicanus*.

Podalirius ursinus Cockerell, 1897c, p. 22. Organ Mountains, and Vega San José, NEW MEXICO.

Robertson, 1898a, p. 242. At *Lonicera sullivantii*.

Cockerell, 1914a, p. 281. Garrison, NEW YORK; (Cattell).

usticauda Cockerell, 1912b, p. 22. ♀. Antigua and Amatitlan, GUATEMALA; II; (W. P. Cockerell). Subgenus *Micranthophora*.

vallorum. See *Anthophoroides*.

versicolor. See *Centris*.

vierecki. See *centrifformis vierecki*.

volucellæformis Dours, 1869, p. 189. ♀. MEXICO.

walshii Cresson, 1869, p. 290. ♂*, ♀. ILLINOIS; (Walsh).

Robertson, 1898a, p. 230. (?) Carlinville, ILLINOIS; at *Lespedeza reticulata* and, 1899, p. 36, at *Cassia chamaecrista*.

Amegilla walshii Robertson, 1905, p. 372.

Cockerell, 1906, pp. 65, 66, 70, 100. Fedor, TEXAS; (Birkman). At *Cassia*.

Grænicher, 1907, p. 26. ♀. WISCONSIN; at *Allium cernuum*.

Cockerell, 1909, p. 26. Malcolm, NEBRASKA; IX; at *Salvia*.

Grænicher, 1911, p. 248. Mouth of Yellow River, Burnett County, WISCONSIN; VII or VIII; at *Rudbeckia hirta*.

See *smithii*.

washingtoni Cockerell, Viereck *et al.*, 1905, p. 313. ♀. Pasco, WASHINGTON; V; (Kincaid).

Cockerell, 1906b, p. 277. N. Yakima, WASHINGTON; V; (Jenne).

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

watsonia. See *porterae watsoni*.

willingi. See *bomboides willingi*.

ANTHOPHORIDES Cockerell, T. D. A. and W. P., 1901, p. 48(Type: *Podalirius vallorum* Cockerell)

vallorum Cockerell, 1896, p. 195. (*Podalirius*) ♂, ♀. Mesilla and Las Cruces, NEW MEXICO; VI, VIII; at *Solanum elaeagnifolium* and *Ipomæa*.

Podalirius vallorum Cockerell, 1898f, p. 314. Mesilla Park, NEW MEXICO; at *Martynia* and *Chilopsis*.

Anthophora vallorum Cockerell, 1900b, p. 218. Juarez, MEXICO; X: at *Ipomæa mexicana*.

Cockerell, T. D. A. and W. P., 1901, p. 48.

Cockerell, 1906, p. 100. At *Solanum* and *Ipomæa*.

Anthophorula Cockerell

See *Exomalopsis*.

CLISODON Patton, 1879, p. 479(Type: *Anthophora terminalis* Cresson)

Podalirius (Clisodon) Dalla Torre, 1896, p. 252.

neofurcata. See *terminalis neofurcata*.

syringæ Cockerell, 1898b, p. 54. (*Podalirius*). ♂. Olympia, WASHINGTON; VII; at *Syringa*; (Kincaid).

Cockerell, 1906, p. 100.

terminalis Cresson, 1869, p. 292. (*Anthophora*) ♀*, ♂. COLORADO.* DELAWARE. CONNECTICUT. MASSACHUSETTS. CANADA.

Anthophora terminalis Cresson, 1876, p. 210. Empire, COLORADO. Spring Lake, UTAH. (Putnam).

Patton, 1879, p. 479.

Evans, 1896, p. 13. Sudbury, ONTARIO.

Cockerell, 1897c, p. 19. Monument Rock, Santa Fé Canyon, NEW MEXICO; 8000 ft.

Cockerell, 1899, p. 156. Mescalero Indian Agency, Tularosa Creek, NEW MEXICO; VII; (C. M. Barber).

Cockerell, 1901a, p. 131. Beulah, Harvey's Ranch, and Sapello Canyon, NEW MEXICO; VIII; at *Polemonium*; (Porter).

Viereck, 1902, p. 46. Crew's Mesa above Beulah, NEW MEXICO; VI.

Anthophora nubilerræ Viereck, 1902, p. 46. ♂. Beulah, NEW MEXICO; (W. P. Cockerell).

Cockerell, 1903a, p. 891. Truchas Peaks, NEW MEXICO; above timber line; at thistle.

Lovell and Cockerell, 1906, p. 112. Waldoboro, MAINE; at *Pontederia cordata*.

Cockerell, 1906, pp. 72, 100, 311. Steamboat Springs, COLORADO; VIII; (S. A. Johnson). "Arctic-Alpine to Upper Sonoran." Pecos, and Cloudcroft, NEW MEXICO.

Cockerell, 1906*d*, p. 443. Florissant, Teller County, COLORADO; VII; at *Pentstemon*, *Mertensia*, and *Linum lewisii*.

Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VII; (F. H. Snow).

Grænicher, 1907, pp. 24 and 26. ♀. WISCONSIN; at *Allium canadense* and *cernuum*.

Tucker, 1909, p. 278. Tabernash, COLORADO; VIII.

Anthophora terminalis Smith, 1910, p. 694. Riverton, NEW JERSEY; IX.

Grænicher, 1911, p. 248. Solon Springs and Gordon in Douglas County, the mouth of the Nemakagon River, Swiss, the mouth of the Yellow River, Kettle River Rapids, and Randall in Burnett County, Maiden Rock in Pierce County, and Fountain City in Buffalo County, WISCONSIN; VII, VIII.

Crawford, 1913, p. 270. Nerepis, NEW BRUNSWICK; VIII.

Cockerell, 1915, p. 269. Bikerdike Ranch, near Allen's Park, COLORADO; VIII; at *Gentiana affinis*.

Anthophora (Clisodon) terminalis Viereck, 1916, p. 737. Mt. Carmel, CONNECTICUT; VIII.

Sladen, 1918, p. 302. Ottawa, CANADA; at alfalfa; suggests that it is *Anthophora furcata* of Europe.

Cockerell, 1916*c*, p. 6. Floodwood, Schoolcraft County, and Whitefish Point, Chippewa County, MICHIGAN; VII; (Gauge, Andrews).

Anthophora (Clisodon) terminalis Washburn, 1919, p. 231. Itasca Park, MINNESOTA; VIII; at *Aster*.

Sladen, 1919, p. 125. Hull, QUEBEC. Cochrane, ONTARIO. Edmonton, ALBERTA. Agassiz, Shawnigan Lake and Victoria, Vancouver Island, BRITISH COLUMBIA. At *Stachys palustris*. Nests in wood. Same as European *Anthophora furcata*.

Cockerell, 1919*b*, p. 293. Longs Peak Inn and Twin Sisters, COLORADO.

terminalis neofurcata Sladen, 1919, p. 125. ♀. Agassiz, Shawnigan Lake and Victoria, Vancouver Island, BRITISH COLUMBIA.

DASIAPIS Cockerell, 1903, p. 450

(Type *Dasiapis ochracea* Cockerell)

ochracea Cockerell, 1903, p. 450. ♂. Las Cruces* and Santa Fé, NEW MEXICO; VIII; at *Sphaeralcea fendleri lobata*. Has been confused with *Diadasia enavata*.

Cockerell, 1906, pp. 74, 100, 310. Soledad Caynon, Organ Mountains, NEW MEXICO. Oak Creek Canyon, ARIZONA; (Snow).

Cockerell, 1906*b*, p. 281. N. Yakima, WASHINGTON; VI; (Jenne).

olivacea Cresson, 1878*a*, p. 216. (*Melissodes*) ♀*, ♂. MEXICO; (Sumichrast).

Eucera olivacea Dalla Torre, 1896, p. 242.

Cockerell, 1905, p. 15. CALIFORNIA.

Cockerell, 1906*a*, p. 74. Brownsville, TEXAS; VI; (Snow).

Melissodes olivacea Smith, 1910, p. 693. Camden County, New Jersey; (Fox). This record is probably wrong.

tropicalis Cockerell, 1918*b*, p. 27. ♀. Pueblo Viejo, Vera Cruz, MEXICO; XII; (Bishopp).

DIADASIA Patton, 1879, p. 475

(Type: *Melissodes enavata* Cresson)

Dalla Torre, 1896, p. 222, made it a subgenus of *Eucera*. Ashmead, 1899, p. 64, made it a synonym of *Ancyloscelis* Latreille, 1825, p. 363; in this connection, see Cockerell, 1917*b*, p. 304. Cockerell, 1905*b*, pp. 741-745, reviewed the genus.

afflicta Cresson, 1878*a*, p. 217. (*Melissodes*) ♀*, ♂. TEXAS. (Belfrage, Heiligbrodt).

Diadasia tricineta Provancher, 1896, p. 28. ♀. Los Angeles, CALIFORNIA, (Coquillett).

Melissodes afflicta Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Cockerell, 1904*a*, p. 22.

Cockerell, 1914*b*, p. 410. Falfurrias, TEXAS; V; at *Helianthus*; (Morgan).

afflicta perafflicta Cockerell, 1905*b*, p. 744. ♂ (♀ like *afflicta*). Clark (Alt. 1962 ft.), Hamilton (3350 ft.), and Wallace (3000 ft.) counties, KANSAS.

afflictula Cockerell, 1910, p. 366. Mesilla, NEW MEXICO; V.

alboresta Fowler, 1902, p. 321. Misprint for *albovestita*.

albovestita Provancher, 1896, p. 27. ♀. Los Angeles, CALIFORNIA; (Coquillett).

apacha. See *diminuta*.

arctos. See *enavata*.

australis Cresson, 1878*a*, p. 214. (*Melissodes*) ♀*, ♂. COLORADO*; (Ridings, Morrison). TEXAS; (Belfrage).

Patton, 1879, p. 476.

Cockerell, 1893, p. 338. Near Swift Creek, Custer County, COLORADO.

Cockerell, 1898*c*, p. 193. Santa Fé Canyon, NEW MEXICO; 7700 ft.; VI;

at *Opuntia arborescens*. Whitewater, Grant County, NEW MEXICO; VII.

Viereck, 1903*b*, p. 728. San Bernardino, CALIFORNIA; VII; at *Helianthus*; (Cockerell).

Cockerell, 1905*b*, p. 745. Wallace and Morton Counties, KANSAS; (Snow).

Cockerell, 1906, pp. 73, 100, 310. Fedor, TEXAS; (Birkman).

Cockerell, 1914*b*, p. 410. Falfurrias, TEXAS; V; at *Helianthus*; (Morgan).

australis knabiana Cockerell, 1917*b*, p. 304. ♀. Tehuantepec, Oaxaca, MEXICO; VI; (Knab).

australis opuntiae Cockerell, 1901, p. 286. (*Diadasia rinconis opuntiae*) ♀. San Pedro, CALIFORNIA; VII; at *Opuntia*; (W. P. Cockerell).

D. rinconis opuntiae Viereck, 1903*b*, p. 728.

D. rinconis Cockerell, 1905, p. 14. Los Angeles and Palm Spring, CALIFORNIA.

Cockerell, 1906, p. 101.

(?) *D. australis* Cockerell, 1914b, p. 410. San Bernardino, CALIFORNIA; at *Helianthus*.

Bray, 1917, p. 94. Claremont, CALIFORNIA; V; at cactus.

australis rinconis Cockerell, 1897b, p. 154. (*Diadasia rinconis*) ♀.

Rincon, NEW MEXICO; VII; at *Chilopsis saligna* and an asclepiad.

Diadasia rinconis Cockerell, 1904a, p. 24. Pecos, NEW MEXICO; VIII; at *Opuntia arborescens*.

Cockerell, 1905b, p. 745. CALIFORNIA. Bill Williams's Fork and Oak Creek Canyon, ARIZONA; (Snow). Texas (a ♀ cotype of *australis*).

Cockerell, 1906, pp. 101, 311. Las Vegas and Mesilla Valley, NEW MEXICO.

Cockerell, 1917a, p. 191. Point Isabel and San Benito, TEXAS; IV; at cactus and *Argemone*; (W. P. Cockerell).

Bray, 1917, p. 94. Claremont, CALIFORNIA; V; at cactus.

See *australis opuntiae*.

bituberculata Cresson, 1878a, p. 218. (*Melissodes*) ♂. CALIFORNIA; (Crotch).

D. cinerea Fowler, 1899, p. 285. ♂. Berkeley, CALIFORNIA; V, VI.

Cockerell, 1903b, p. 77.

D. cinerea Cockerell, 1905, p. 14. Los Angeles and Rock Creek, CALIFORNIA.

Cockerell, 1905b, p. 745. NEVADA.

Bray, 1917, p. 94. Claremont, CALIFORNIA; V; at cactus.

cinerea. See *bituberculata*.

crassicauda Cockerell, 1915c, p. 231. ♂. Laguna, CALIFORNIA; (La Follette).

densa. See *enavata densa*.

diminuta Cresson, 1878a, p. 215. (*Melissodes*) ♂. COLORADO; (Morrison).

Melissodes apache Cresson, 1878a, p. 217. ♀. TEXAS*. NEW MEXICO. ARIZONA.

D. diminuta Patton, 1879, p. 476.

A. apache Fox, 1893, pp. 21, 118. San Julio, San Esteban, San José de Gracias, and El Paraiso, Lower California, MEXICO; IV, V, X; (Haines).

Cockerell, 1897c, p. 20. Santa Fé (7000 ft.) and Mesilla Valley (3800 ft.), NEW MEXICO. Juarez, MEXICO.

Cockerell, 1898, p. 193. Mesilla Valley, NEW MEXICO; at *Sphaeralcea angustifolia* and roses.

Cockerell, 1900, p. 363. Las Vegas, NEW MEXICO; at *Sphaeralcea fendleri lobata*, *S. cuspidata*, *Malvastrum coccineum*, *M. dissectum* and *Sidalcea neomexicana*.

Cockerell, 1903, p. 444. Mescalero, NEW MEXICO; X; at *Sphaeralcea fendleri*.

Cockerell, 1905, p. 15. Palm Spring, CALIFORNIA.

Cockerell, 1905b, p. 745. Hamilton County, KANSAS; (Snow).

Cockerell, 1906, pp. 101, 311. Gives synonymy.

Crawford, 1912, p. 359. Medicine Hat, ALBERTA; (Malloch).

enavata Cresson, 1872, p. 280. (*Melissodes*) ♀. Bosque County (?), TEXAS*; (Belfrage).

Melissodes ? *ursina* Cresson, 1872, p. 281. ♂. TEXAS; (Belfrage, Boll).

Patton, 1879, p. 476.

Cockerell, 1893, p. 338. West Cliff, Custer County, COLORADO; VII.

Fox, 1893, p. 21. Comodu, Lower California, MEXICO; III; (Haines).

Townsend, 1896, p. 138. Las Cruces, NEW MEXICO; VIII.

Eucera arctos Dalla Torre, 1896, p. 225. N. n. for *Melissodes ursina* Cresson, not Haliday.

Cockerell, 1897c, p. 20. Santa Fé (7000 ft.), Mesilla Valley (3800 ft.) and Soledad Canyon, Organ Mountains, NEW MEXICO; (1898f, p. 79) sleeping in closed flowers of *Argemone platyceras*.

Cockerell, 1898c, p. 193. Mesilla Valley, IX, at *Bigelovia wrightii* and *Verbesina encelioides*; Santa Fé, VIII; Rincon, VII, at *Chilopsis*; Lone Mountain, near Silver City, VII, at *Sidalcea malyziflora*; Deming, VII, at *Verbesina encelioides*; and Clora'o, VII, at *Sphaeralcea angustifolia*;—all, NEW MEXICO.

Fowler, 1899, p. 286. Santa Catalina Island, Santa Barbara, and Redlands, CALIFORNIA; VI.

Cockerell, 1905b, p. 745. ARIZONA. Wallace County, KANSAS; (Snow). Lamar, Palisade, Julesburg, and Trinidad, COLORADO.

Cockerell, 1905h, p. 218. Mesilla, NEW MEXICO; VII; at *Helianthus annuus*.

Cockerell, 1906, pp. 73, 101, 311. Fedor, TEXAS; (Birkman). At *Helianthus*. Gives synonymy.

Cockerell, 1916b, p. 77. Orange, CALIFORNIA; VIII; at *Helianthus lenticularis*.

enavata densa Cresson, 1872, p. 282. (*Melissodes* ? *densa*) ♂. Bosque County (?), TEXAS*, (Belfrage).

Melissoides densa Cresson, 1876, p. 210. Spring Lake, UTAH. Boulder, COLORADO. (Putnam).

Diadasia, Syn. of *enavata*, Patton, 1879, p. 476.

Cockerell, 1905b, p. 745. Rocky Ford, COLORADO.

friesei Cockerell, 1898c, p. 192. ♀. Southern CALIFORNIA.

knabiana. See *australis knabiana*.

laticauda Cockerell, 1905, p. 103. ♀. Los Angeles, CALIFORNIA: (Davidson).

megamorpha Cockerell, 1898c, p. 192. ♂, ♀. Mesilla Valley*, IX, and Whitewater by the White Sands, X, NEW MEXICO; at *Sphaeralcea fendleri lobata*, not *angustifolia* (See Cockerell, 1905b, p. 745).

nerea. See *nigrifrons*.

nigrifrons Cresson, 1878a, p. 195. (*Melissodes*) ♀. CALIFORNIA; (Crotch).

Diadasia nerea Fowler, 1899, p. 285. ♀, ♂. Tulare, CALIFORNIA; V; (H. O. Woodworth).

D. nerea Cockerell, 1905, pp. 14, 105. Los Angeles and Banning, CALIFORNIA.

Cockerell, 1906, p. 101. Gives synonymy.

nitidifrons Cockerell, 1905, p. 104. ♂. Banning, CALIFORNIA. (Davidson).

Cockerell, 1909b, p. 206. N. Yakima, WASHINGTON; VI; (Jenne).

See *skinneri*.

opuntiae. See *australis opuntiae*.

perafflicta. See *afflicta perafflicta*.

piercei Cockerell, 1911, p. 132. ♂*, ♀. Corpus Christi*, TEXAS; III; at *Opuntia*; (W. D. Pierce). Beeville, TEXAS; IV; at *Opuntia*; (Marlatt). "A species of the Lower Austral Zone."

rinconis. See *australis rinconis*.

skinneri Cockerell, 1909b, p. 206. ♂. N. n. for *nitidifrons* Cockerell, 1906, p. 73. Silver Lake, Wasatch Mountains, UTAH; 8600 ft.; VII; (Skinner).

sphaeralcearum Cockerell, 1905b, p. 744. ♂. Between Las Cruces and Mesilla Park, NEW MEXICO; VIII; at *Sphaeralcea fendleri lobata*.

sumichrasti Cresson, 1878a, p. 218. (*Melissodes*). ♀*, ♂. MEXICO; (Sumichrast).

Cockerell, 1904a, p. 22.

See *Ptilothrix* and Cockerell, 1917b, p. 304.

toluca. See *Leptergatis*.

tricincta. See *afflicta*.

ursina. See *enavata*.

Diadasia Ashmead

See *Exomalopsis*.

Dipedia

See *Leptergatis*.

EMPHOR Patton, 1879, p. 476

(Type: *Melissodes bombiformis* Cresson)

Dalla Torre, 1896, p. 221, made *Emphor* a subgenus of *Eucera*.

bombiformis Cresson, 1878a, p. 219. (*Melissodes*) ♀*, ♂. KANSAS.* GEORGIA. VIRGINIA.

See *Melissodes nigripes* Smith, 1854, p. 311. ♀ (not ♂), according to Robertson, 1900, p. 53.

Emphor bombiformis Patton, 1879, p. 476.

Robertson, 1891a, p. 581. At *Ipomæa pandurata*.

Robertson, 1899, p. 36. Presumably Carlinville, ILLINOIS; at *Hibiscus lasiocarpus*.

Viereck, 1903a, p. 119. Chestertown, Maryland; (Vanatta). Gloucester County, New Jersey; (Fox). VIII. [This New Jersey record is doubtful for *fuscojubatus* (see Smith, 1910) and the Maryland one may be.]

Cockerell, 1906, p. 100. At *Hibiscus* and *Ipomæa*.

Knab, 1911, p. 170. "Drinking" habits. See Robertson, 1918, p. 320.

Robertson, 1914, p. 71. "Nests in the neighborhood of the *Hibiscus* on which it depends."

Bequaert, 1918, p. 126. Sabine River, LOUISIANA.

See *fuscojubatus*.

fuscojubatus Cockerell, 1913, p. 107. ♀. Cape May Point, NEW JERSEY; VIII; (Miss L. Nichols).

E. bombiformis Smith, 1910, p. 694. Arlington and Gloucester County, NEW JERSEY; VIII; at *Ipomæa* and *Hibiscus*.

E. bombiformis Grossbeck, 1911, pp. 238-244. Habits.

Nichols, 1913, pp. 107-112. Habits.

nigripes. See *bombiformis*.

EMPHOROPSIS Cockerell, T. D. A. and W. P., 1901, p. 48

(Type: *Anthophora floridana* Smith)

Ashmead, 1899, p. 60, named the genus but assigned no species.

Dalla Torre, 1896, placed all of the described species in *Podalirius*, of which he accepted *Habropoda* Smith, 1854, p. 320 as a subgenus.

Meliturgopsis Ashmead, 1899, p. 62. See Cockerell, T. D. A. and W. P., 1901, p. 49; also Cockerell, 1901a, p. 49, 1903b, p. 77, and 1909a, p. 414. Vachal, 1909, p. 9, gave this name generic rank with *aurulentocaudata* as the type, but this can not stand as it disagrees with Ashmead's original interpretation.

agilis Smith, 1879, p. 118. (*Habropoda*) ♂. Oaxaca, MEXICO.

Cockerell, 1904d, p. 302.

albiceps Friese, 1916, p. 333. (*Anthophora*) ♀. Jacubaya [Tacubaya?], MEXICO. Allied to "*aureolentocaudata*."

aureolentocaudata. See *aurulentocaudata*.

aurulentocaudata Dours, 1869, p. 92. (*Anthophora*) ♀, ♂. MEXICO.

Habropoda aurulentocaudata Patton, 1879, p. 479.

Podalirius aureolentocaudatus Dalla Torre, 1896, p. 258.

Cockerell, 1906, p. 100.

birkmanni Cockerell, 1905c, p. 265. ♀. Fedor, Lee County, TEXAS; III; (Birkman).

bombyformis Smith, 1879, p. 119. (*Habropoda*) ♂. Oaxaca, MEXICO.

Podalirius bremsiformis Dalla Torre, 1896, p. 261. N. n. because he included *Saropoda bombiformis* Smith in *Podalirius*.

Cockerell, 1904d, p. 302.

bremsiformis. See *bombyformis*.

cineraria Smith, 1879, p. 124. (*Anthophora*) ♀, ♂. Vancouver Island, BRITISH COLUMBIA.

Cockerell, 1904d, p. 302.

Cockerell, 1906b, p. 277. Yakima, WASHINGTON; IV.

cressonii. See *mucida*.

depressa Fowler, 1899, p. 283. (*Habropoda*) ♀, ♂. Berkeley, CALIFORNIA; II to V. Santa Catalina Island, CALIFORNIA; VI; (Woodworth.) At *Cytisus proliferus*, oak, and *Ranunculus californicus*; nests described.

Cockerell, 1906, p. 100.

elefas Friese, 1916, p. 334. (*Anthophora*) ♂. Jacubaya [Tacubaya?], MEXICO. Allied to "*aureolentocaudata*."

fedorensis. See *floridana fedorensis*.

floridana Smith, 1854, p. 339. (*Anthophora*) ♀, ♂. St. John's Bluff, eastern FLORIDA.

Anthophora floridana Cresson, 1869, p. 291. PENNSYLVANIA. ILLINOIS.

Habropoda floridana Patton, 1879, p. 478.

Habropoda floridana Fowler, 1899, p. 283. Redonda, CALIFORNIA; V; (Woodworth).

Cockerell, 1904d, p. 302.

Cockerell, 1905, p. 14. Los Angeles, CALIFORNIA.

Cockerell, 1905c, p. 265, and 1905f, p. 182. GEORGIA.

Anthophora floridana Smith, 1910, p. 694. Orange Mountains; Jamesburg, V; Lahaway, VI; Clematon, IV, V; Mannmuskin, IV;—all, NEW JERSEY.

Anthophora (Emphoropsis) floridana Viereck, 1916, p. 737. New Haven, CONNECTICUT; IV.

See *pascoensis*.

The California records seem doubtful.

floridana fedorensis Cockerell, 1905c, p. 265. ♂, ♀. Fedor, Lee County, TEXAS; III, IV; (Birkman).

fulva Smith, 1879, p. 119. (*Habropoda*) ♂. GUATEMALA.

Cockerell, 1904a, p. 204. Mexico (?).

habropoides. See *terminata*.

infernalis. See *tristissima* and *Anthophora*.

interspersa Cockerell, 1905, pp. 99, 100. ♂. CALIFORNIA.

johnsoni Cockerell, 1905*d*, p. 59. (*mucida johnsoni*) ♀*, ♂. Fort Collins*, COLORADO; V; at *Delphinium*; (S. A. Johnson). Lamar, COLORADO; (Gillette).

Cockerell, 1905, p. 99.

Cockerell, 1910*a*, p. 310. Steamboat Springs, COLORADO; 6680 ft.

melanopyrrha Dours, 1869, p. 90. (*Anthophora*) ♀, ♂. MEXICO.

Habropoda melanopyrrha Patton, 1879, p. 479.

Cockerell, 1906, p. 100.

miserabilis Cresson, 1878*a*, p. 191. (*Anthophora*) ♂. CALIFORNIA: (H. Edwards).

Habropoda miserabilis Patton, 1879, p. 479.

Habropoda miserabilis Fowler, 1899, p. 284. ♀. San Francisco, CALIFORNIA; IV; at *Phacelia californica*.

Cockerell, 1906, p. 100.

montezumia Smith, 1879, p. 118. (*Habropoda*) ♂. Oaxaca, MEXICO.

Cockerell, 1904*d*, p. 302.

morrisoni Cresson, 1878*a*, p. 192. (*Anthrophora*) ♂. COLORADO; (Morrison).

Habropoda morrisoni Patton, 1879, p. 479.

Cockerell, 1905, p. 100. ♂ of *mucida*?

mucida Cresson, 1878*a*, p. 191. (*Anthophora*) ♀. COLORADO; (Morrison).

Habropoda mucida Patton, 1879, p. 479.

Podalirius cressonii Dalla Torre, 1896, p. 264. N. n. because he included *Anthophora mucida* Griboda in *Podalirius*.

Cockerell, 1906, p. 100. Suggests that it is the ♀ of *morrisoni*.

Cockerell, 1906*d*, p. 443. Florissant, COLORADO; VI; at *Ribes longiflorum*. See *johnsoni*.

murihirta Cockerell, 1905*a*, p. 81. ♂, ♀. Los Angeles, CALIFORNIA; (Davidson).

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

murihirta murina Cockerell, 1909*a*, p. 414. ♂. San Francisco County, CALIFORNIA; X.

murina. See *murihirta murina*.

pascoensis Cockerell, 1898*b*, p. 54. (*Habropoda floridana pascoensis*) ♀. Pasco, WASHINGTON; V; (Kincaid).

Cockerell, 1905*c*, p. 265.

rugosissima Cockerell, 1905*f*, p. 182. ♀. NEVADA.

salviarum Cockerell, 1897*c*, p. 42. (*Habropoda*) ♂, ♀. Top of Organ Mountains, NEW MEXICO; VIII; at *Salvia*; (Townsend and Tinsley).

Cockerell, 1904, p. 234. Blue River, ARIZONA; (Davidson).

semifulva Cockerell, 1905, p. 99. ♂. CALIFORNIA.

terminata Smith, 1879, p. 119. (*Habropoda*) ♀, ♂. Oaxaca, MEXICO.

Podalirius habropoides Dalla Torre, 1896, p. 271. N. n. because he included *Anthophora terminata* Smith in *Podalirius*.

Cockerell, 1904*d*, p. 302.

tristissima Cockerell, 1904*e*, p. 161. (*Emphoropsis infernalis tristissima*) ♀. Los Angeles and Lancaster (Mohave Desert), CALIFORNIA; (Davidson).

Cockerell, 1906, p. 100.

Cockerell, 1916, p. 283. Claremont, CALIFORNIA; (Baker).

vierecki Cockerell, 1909*a*, p. 414. Name for "n. sp. Viereck, ined.," Cockerell, 1905*c*, p. 265. COLORADO. NEW MEXICO.

ENTECHNIA Patton, 1879, p. 476

(Type: *Anthophora taurea* Say)

It seems quite probable that the name *Entechnia* must give way to *Melitoma*. See Latreille, 1825, p. 464; Lepeletier, 1825, p. 529; Friese, 1899*a*, p. 273; Vachal, 1909, p. 5; Ducke, 1912, p. 95 (mixes a number of quite different genera); and Cockerell, 1917*b*, p. 304.

dakotensis. See *grisella*.

euglossodes. See *fulvifrons*.

fulvifrons Smith, 1854, p. 341. (*Anthophora*) ♀. Pará, Santarem, BRAZIL.

Anthophora fulvifrons Dours, 1869, p. 134. ♀, ♂. Brazil.

Cresson, 1887, pp. 304, 305. Includes his *Melissodes ? marginella*. See *euglossoides marginella*.

Eucera marginella and *Podalirius fulvifrons* Dalla Torre, 1896, pp. 240, 269. Cockerell, 1899*b*, p. 14. Lower part of Rio Nautla, MEXICO.

Meliphila impomæa Schrottky, 1902, p. 311. ♂, ♀. Buenos Ayres and État de St. Paul, BRAZIL; at *Ipomæa eriocarpa*.

Podalirius fulvifrons Schrottky, 1903, p. 524.

Cockerell, 1905*c*, p. 335. Fedor, Lee County, TEXAS; VIII. ARGENTINA. BOLIVIA.

Crawford, 1906, p. 161. Juan Vinas and Monte Redondo (about 4000 ft.), COSTA RICA; III; (Bruner).

Anthophora taurea fulvifrons Friese, 1916, p. 295. San José, COSTA RICA; (Schmidt).

Probably the same as *euglossoides*.

fulvifrons marginella Cresson, 1872, p. 282. (*Melissodes ? marginella*) ♂, ♀*. Comal County*, TEXAS. MEXICO.

Melitoma euglossoides marginella Cockerell, 1914c, p. 316. Guatemala City, (Rodriguez), and Quirigua, (W. P. Cockerell), GUATEMALA Rio Nautla, MEXICO; (Townsend).

grisella Cockerell and Porter, 1899, p. 409. ♂. La Cueva, Gallinas River, S. of Las Vegas, NEW MEXICO; VIII; (Porter). Cockerell, 1906, p. 310, gives Las Valles as the type locality. (La Cueva was a mistake.)

Entechnia dakotensis Cockerell and Porter, 1899, p. 409. ♀. Hot Springs, DAKOTA; (L. Bruner).

Cockerell, 1906, pp. 73, 99. Gives this synonymy. Rocky Ford and Denver, COLORADO; (S. A. Johnson). Wallace County, KANSAS; 3000 ft.: (SNOW). NEBRASKA; at *Ipomæa leptophylla*; (Crawford).

ipomæa. See *fulvifrons*.

marginella. See *fulvifrons* and *fulvifrons marginella*.

taurea Say, 1837, p. 410. (*Anthophora*) ♀, ♂. INDIANA; describes nest.

Anthophora taurea Dours, 1869, p. 149. MEXICO. Describes but does not name a variety.

Patton, 1879, p. 476.

Robertson, 1891a, pp. 571, 581. At *Asclepias incarnata*, *Ipomæa pandurata*, and *Convolvulus sepium*.

Podalirius taureus Dalla Torre, 1896, p. 291.

Robertson, 1901a, p. 367. An oligotropic visitor of *Ipomæa pandurata*.

Holmberg, 1903, p. 400. North America to Buenos Ayres, ARGENTINA.

Cockerell, 1906, p. 99. ILLINOIS and GEORGIA; at *Convolvulus*.

Melitoma taurea Smith, 1910, p. 694. Fort Lee and Camden County, NEW JERSEY; VI.

Robertson, 1914, p. 68. *Triepeolus donatus* is inquiline.

See *fulvifrons*.

toluca. See *Leptergatis*.

LEPTERGATIS Holmberg, 1903, p. 422

Holmberg's first species, *L. halictoides* Holmberg, may be considered the type. This is said to be identical with *Dipedia gigas* Friese. See p. 641.

Dipedia Friese, 1906, p. 92. Type: *Ancyloscelis armata* Smith. **armata** Smith, 1854, p. 367. (*Ancyloscelis*) ♂. BRAZIL.

Ancyloscelis armatus Cockerell, 1905e, p. 325. Discusses generic position.

Cockerell, 1902b, p. 29. Quirigua, GUATEMALA; II; at *Zexmenia virgulta*; (W. P. Cockerell).

toluca Cresson, 1878a, p. 219. (*Melissodes*) ♀*, ♂. MEXICO; (Sumichrast).

Diadasia toluca Fox, 1893, p. 118. San José del Cabo, Lower California, MEXICO; X; (Eisen).

Eucera toluca Dalla Torre, 1896, p. 249.

Entechnia toluca Cockerell, 1905b, p. 741.

Cockerell, 1912b, p. 29. Gualan, GUATEMALA; II; at *Cordia alba*; (W. P. Cockerell).

wheeleri Cockerell, 1912, p. 105. ♂. Escuintla, GUATEMALA; XII; (Wheeler).

Habropoda

See *Emphoropsis*.

Meliturgopsis

See *Emphoropsis*.

Melitoma

See *Entechnia*.

Micranthophora

See *Anthophora*.

Eucerinae

ANTHEDON Robertson, 1900, p. 53

(Type: *Melissodes compta* Cresson)

compta Cresson, 1878a, p. 199. (*Melissodes*) ♀*, ♂. GEORGIA; (Morrison).

Robertson, 1901a, p. 367. An oligotrope of *Oenothera biennis* at Carlinville, ILLINOIS.

Cockerell, 1905c, p. 267. Fedor, Lee County, TEXAS; VI.

Cockerell, 1906, p. 79. Cheyenne Mountain, near Colorado Springs, COLORADO; VII; (Gillette).

Melissodes compta Smith, 1910, p. 693. Westville, NEW JERSEY. Philadelphia, PENNSYLVANIA. VII.

Melissodes (Anthedon) compta Viereck, 1916, p. 732.

CEMOLOBUS Robertson, 1902, pp. 324, 325

(Type: *Xenoglossa ipomææ* Robertson)

ipomææ Robertson, 1891a, p. 581, and 1898, p. 65. (*Xenoglossa*) ♀. Carlinville, ILLINOIS; VII, VIII; at *Ipomæa pandurata*.

Robertson, 1902, pp. 324, 325. ♀, ♂.

Cockerell, 1906, pp. 101, 106. Lehigh Gap, PENNSYLVANIA; (Rehn).

Epimelissodes Ashmead

See *Melissodes*.

Eucera Scopoli

Dalla Torre, 1896, included practically all of our eucerine bees in this genus.

"*Eucera* Scop. is European. *E. maculata* Lep., if correctly placed generically, is probably wrongly attributed to North America" (Cockerell, 1906, p. 104).

Eusynhalonia Ashmead

See *Tetralonia*.

Euthyglossa Radoszkowsky, 1884, p. 21

This genus is probably a synonym of *Osiris* (see Cockerell, 1906, p. 104). At any rate, *fasciata* Radoszkowski, 1884, p. 22 (*Eucera euthyglossa* Dalla Torre, 1896, p. 232), does not belong to the groups treated here.

FLORILEGUS Robertson, 1900, p. 53

(Type: *Melissodes condigna* Cresson)

Cockerell, 1906, p. 107, questions the validity of the genus.

condigna Cresson, 1878a, p. 207. (*Melissodes*) ♀. ILLINOIS and KANSAS.*

Melissodes palustris Robertson, 1892, p. 273. ♂. Carlinville, ILLINOIS; at *Dianthera americana* and *Pontederia cordata*. See 1898, p. 53.

Cockerell, 1909c, p. 129. ♀. Plano (about 17 miles N. of Dallas), TEXAS; X; (Tucker).

Melissodes (Florilegus) condigna Viereck, 1916, p. 732.

lanierii Guérin, 1845, p. 455, Pl. LXXIV, fig. 7. (*Macrocera*) ♂. CUBA.

Tetralonia lanierii Smith, 1854, p. 308.

Melissodes lanierii Cresson, 1865, p. 188.

Cockerell, 1906, p. 77.

palustris. See *condigna*.

Macrocera

See *Tetralonia*.

Macroglossa

See *Thygater*.

Macroglossapis

See *Thygater*

MARTINELLA Cockerell, 1903, p. 450

(Type: *Melissodes luteicornis* Cockerell)

Proposed as a subgenus of *Melissodes*.

luteicornis Cockerell, 1896a, p. 293. (*Melissodes*) ♂. Rincon and Colorado, NEW MEXICO; VII; at *Prosopis juliflora glandulosa*.

Melissodes luteicornis Cockerell, 1898f, p. 314. Las Cruces, NEW MEXICO; at *Cevallia sinuata*.

Cockerell, 1906, p. 310. Mesilla Valley, NEW MEXICO.

MELISSODES Romand, 1841, Pl. LXX

(Type: *Melissodes fonscolombeii* Romand)

Cockerell, 1912d, p. 267: "*Melissodes* is usually credited to Latreille, but it was defined, and species assigned to it, by F. Smith in 1854. Lepeletier described what was understood to be Latreille's insect as *Melissoda latreillii*; this is *Acanthopus goryi* Romand. Mr. J. C. Crawford writes in a letter that Romand in 1841 included a species in *Melissodes*; I have not had access to this work." Apparently Romand is the real author of the genus. Romand's account of *Melissodes fonscolombeii* is extremely confused, and his figures are bad. He supposed he had both sexes of a single species, the male from the Antilles, the female from Chili. In a postscript he states that the true insect of Latreille is from the Antilles. The figures indicate that the two insects were both males; one, presumably from the Antilles, a *Melissodes* in the modern sense; the other a *Diadasia*. His Figure 6 shows well the apex of the abdomen of ♂ *Diadasia*, and 5 B appears to be a *Diadasia* leg, with thickened femur. But figures 1 A, 2, 3, 5 A and 7 all indicate male *Melissodes*. The light clypeus and long antennæ are well shown, and the wing agrees, except that the third submarginal cell is too broad above. We propose to restrict the name to the last mentioned, thereby conserving *Melissodes* in the sense of modern authors and of Latreille. Unless *fonscolombeii* can be definitely identified by finding the type or in some other way the justice of crediting the genus to Romand may be questioned.

Dalla Torre, 1896. Includes *Melissodes* under *Eucera*.

Epimelissodes Ashmead, 1899, p. 163 (Type: *M. atripes* Cresson) might be considered a subgenus.

For keys, etc., see Robertson, 1905, and Cockerell, 1905e, 1905h, 1906, and 1912d.

acerba. See *Tetralonia*.

acomanche. See *atripes acomanche*.

actuosa. See *Tetralonia*.

afflicta. See *Diadasia*.

agilis Cresson, 1878a, p. 204. ♂. TEXAS; (Belfrage).

Cockerell, 1894, p. 234. Juárez, MEXICO; VIII.

Robertson, 1896, p. 176. Carlinville, ILLINOIS; at *Silphium perfoliatum*.

Cockerell, 1897c, pp. 23, 24, 28. Socorro, Mesilla Valley, and Organ Mountains, NEW MEXICO.

Cockerell, 1898a, pp. 67, 73. Albuquerque, NEW MEXICO; at *Helianthus annuus*. 1898f, pp. 312 and 314: Las Cruces, NEW MEXICO.

Cockerell, 1901a, p. 129. Las Vegas, Sapello Canyon, and San Ignacio, NEW MEXICO; VII, VIII; at *Helianthus annuus*, *Verbesina encelioides*, and *Cleome serrulata*. Var. α , σ , has no yellow spot on mandibles.

Cockerell, 1905, pp. 13, 28, 29. Notes variations, without naming them, from Bear Valley, Rock Creek, Los Angeles, and Catalina Island, CALIFORNIA; (Davidson).

Lovell and Cockerell, 1906, p. 110. Waldoboro, MAINE; VIII, IX; at *Helianthus*.

Cockerell, 1906, pp. 102, 309. COLORADO. Santa Fé, Las Vegas, and San Ignacio, NEW MEXICO. "Transition to Middle Sonoran Zones."

Cockerell, 1907b, p. 255. Boulder, COLORADO; VIII; at *Grindelia*.

Tucker, 1909, p. 278. Colorado Springs and Denver, COLORADO; VIII.

Cockerell, 1910d, p. 128. Rifle Gap, COLORADO; at *Helianthus*; (Robbins). Remarks on variation.

Grænicher, 1911, p. 247. Mouth of the Yellow River and Randall in Burnett County, Farmington in Polk County, Hudson in St. Croix County, and Prescott and Maiden Rock in Pierce County, WISCONSIN; VII, VIII; at *Compositæ*.

Cockerell, 1914d, p. 365. Fresno, CALIFORNIA; VIII.

See *lupina*.

agilis aurigena Cresson, 1878a, p. 212. (*M. aurigena*) ♀*, ♂. CANADA. MAINE. NEW YORK. VIRGINIA. LOUISIANA. MISSOURI. KANSAS. COLORADO.* NEW MEXICO. UTAH.

M. aurigena Robertson, 1894, pp. 452-475. Macoupin County, ILLINOIS; at *Eupatorium purpureum*, *Lacinia* ["*Liatris*"] *pycnostachya*, *Aster novæ-angliæ*, *Silphium integrifolium* and *laciniatum*, *Lepachys pinnata*, *Helianthus grosseserratus* and *tuberosus*, *Coreopsis aristosa*, *Bidens chrysanthemoides*, *Helenium autumnale*, and *Cnicus lanceolatus*.

M. agilis Robertson, 1897, p. 354. Made *aurigena* a synonym of *agilis*. Carlinville, ILLINOIS.

M. aurigena Robertson, 1898a, p. 244. At *Helianthus divaricatus*.

M. aurigena Cockerell, 1897c, p. 20. Santa Fé, NEW MEXICO; 7000 ft.; (1898f, p. 79) sleeping in closed flowers of *Argemone platyceras*.

Cockerell, 1898a, pp. 67, 73. Albuquerque, NEW MEXICO; IX; at *Helianthus annuus*.

Cockerell, 1901a, p. 129. Romeroville and Las Vegas, NEW MEXICO; VII, VIII; at *Medicago sativa*, *Verbesina encelioides*, and *Aplopappus spinulosus*.

M. aurigena Cockerell, 1905, p. 103. Phoenix, ARIZONA; X.

M. aurigena Cockerell, 1906, p. 92. Oak Creek Canyon, ARIZONA; (Snow). Sterling, Durango, Greeley, and Fort Collins, COLORADO.

M. aurigena Tucker, 1909, p. 278. Colorado Springs and Denver, COLORADO; VII, VIII.

M. aurigena Cockerell, 1911, p. 390. Sterling, COLORADO; VIII; at *Helianthus*.

M. aurigena Cockerell, 1914b, p. 409. Goodview, COLORADO; VII; at *Helianthus annuus coronatus*.

M. aurigena Cockerell, 1915b, p. 482, and 1916b, p. 77. Orange, CALIFORNIA; VIII; at *Helianthus lenticularis*.

agilis semiagilis. See *semiagilis*.

agilis snowii. See *snowii*.

agilis subagilis Cockerell, 1905d, p. 145. ♂. Fort Collins, COLORADO; VIII; at *Grindelia squarrosa*; (Bishopp).

Cockerell, 1906, pp. 76, 92, 102. Oak Creek Canyon, ARIZONA; (Snow).

Cockerell, 1906c, p. 367. Fedor, Lee County, TEXAS; (Birkman).

albata. See *Xenoglossodes*.

albilabris. See *Thygater*.

albocincta Cockerell, 1919a, p. 119. ♀. MEXICO; (Baker). "This may be referable to *Xenoglossodes*."

albicollaris Cockerell, 1919b, p. 30. MEXICO; (Baker).

ambigua Smith, 1879, p. 116. ♀. MEXICO.

americana Lepeletier, 1841, p. 92. (*Macrocera*) ♂. CAROLINA.

Smith, 1854, p. 312.

Robertson, 1898, p. 53. Says that *dentiventris* Robertson, 1897, p. 353, is this species. 1898a, p. 244: (?) Carlinville, ILLINOIS; at *Helianthus divaricatus*.

apacha. See *Diadasia diminuta*.

apicata Lovell and Cockerell, 1906, p. 111. ♀. Waldoboro, MAINE; VII; at *Pontederia cordata*.

aschenborniana. See *tepaneco aschenborniana*.

assimilis. See *Xenoglossa*.

asteris Robertson, 1914, pp. 70, 373. ♀. Carlinville, ILLINOIS; at *Asteroideæ*.

atrata Smith, 1879, p. 115. ♂. Oaxaca, MEXICO.

Eucera atratula Dalla Torre, 1896, p. 225.

Cockerell, 1896a, p. 290. Paso de Telaya, Vera Cruz, MEXICO; IV; (Townsend).

Cockerell, 1899b, p. 13. Oaxaca and lower part of Rio Nautla, MEXICO.

atratula. See *atrata*.

atrifera Cockerell, 1910, p. 256. ♂. MEXICO; (Deppe).

atrifera sandiarum Cockerell, 1910, p. 257. ♂. Sandia Mountains NEW MEXICO; VII; at *Croton*; (Watson).

atrifrons. See *carolinensis*.

atripes Cresson, 1872, p. 275. ♀. TEXAS; (Belfrage).

Robertson, 1898, p. 54. Carlinville, ILLINOIS. 1914, p. 73: at *Cassia chamaecrista*.

Epimelissodes atripes Ashmead, 1899, p. 63.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS; VI (See Cockerell, 1905c, p. 335.)

Smith, 1910, p. 693. Camden County, NEW JERSEY; (Fox).

atripes acomanche Cockerell, 1906, p. 109. ♂. Fedor, Lee County, TEXAS; VI; (Birkman).

atriventrís. See *Tetralonia*.

aurigenia. See *agilis aurigenia*.

australis. See *Diadasia*.

autumnalis Robertson, 1905, p. 369, for Robertson, 1896, pp. 175, 178 (manuscript name). ♀, ♂. Carlinville, ILLINOIS; at *Aster ericoides villosus* and *Rudbeckia laciniata*.

Cockerell, 1906, p. 114. Fedor, Lee County, TEXAS; XI; (Birkman).

baileyi Cockerell, 1906c, p. 361. ♀. Fedor, Lee County, TEXAS; IV; (Birkman).

belfragii. See *Tetralonia*.

bidentis Cockerell, 1914d, p. 362. ♀. West Point, NEBRASKA; IX; at *Bidens*; (Crawford).

bimaculata Lepeletier, 1825, p. 527. (*Macrocera*) ♀. PENNSYLVANIA.

Macrocera binotata Say, 1837, p. 404. ♀, ♂. INDIANA.

Macrocera nigra Lepeletier, 1841, p. 241. PENNSYLVANIA.

Melissodes nigra Smith, 1854, p. 310.

Robertson, 1891a, pp. 569, 581, 587, 593, 594. At *Asclepias verticillata*, *Ipomæa pandurata*, *Convolvulus sepium*, *Scrophularis nodosa marilandica*, *Veronica virginica*, and *Seymaria macrophylla*.

Robertson, 1894, pp. 451, 452, 463, 469, 473, 476. Macoupin County, ILLINOIS; at *Vernonia fasciculata* (printed *noveboracensis* but changed by the author in copies sent out), *Eupatorium purpureum*, *Silphium laciniatum*, *Lepachys pinnata*, *Coreopsis aristosa*, and *Cnicus lanceolatus*.

Robertson, 1896, pp. 162, 176, 178. Carlinville, ILLINOIS; at *Astragalus canadensis*, *Silphium perfoliatum*, and *Cacalia reniformis*.

Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

Harris and Kuchs, 1902, p. 36. Lake View, KANSAS; at *Cassia chamaecrista*.

Cockerell, 1905c, p. 267. Wellsville, KANSAS; (Johnson).

Smith, 1910, p. 693. Staten Island, NEW YORK. New Brunswick, Jamesburg, Westville, Riverton, Merchantville, Collingswood and Winslow, NEW JERSEY. VII, VIII.

Grænicher, 1911, p. 247. Prescott and Maiden Rock, Pierce County, WISCONSIN; VII, VIII.

Viereck, 1916, p. 733. New Haven and Westville, CONNECTICUT; VII.

bimaculata morrilli Cockerell, 1918b, p. 29. ♀. Tlahualilo, Durango, MEXICO; IX; at squash; (Morrill).

binotata. See *bimaculata*.

bishoppi Cockerell, 1914b, p. 414. ♂. Paris, TEXAS; VIII; at *Helianthus*; (Bishopp).

bituberculata. See *Diadasia*.

blakei Cockerell, 1905i, p. 523. ♀. Beulah, NEW MEXICO; VIII. "Canadian zone."

Cockerell, 1906, pp. 107, 309. Tularosa Creek, NEW MEXICO; X; at *Chrysothamnus graveolus glabrata*. "May prove to be a mountain race of *mizea*." "Canadian to Upper Sonoran."

boltoniae Robertson, 1905, p. 368. ♀. Carlinville, ILLINOIS.

Cockerell, 1907e, p. 127. Falls Church, VIRGINIA; VIII, IX; (Banks).

Cockerell, 1909, p. 26. Malcolm, NEBRASKA; IX; (Birkman).

bombiformis. See *Emphor*.

brevicornis. See *Xenoglossa*.

bruesi Cockerell, 1906, p. 110. ♀. Fedor, Lee County, TEXAS; V; (Birkman).

cajennensis Lepeletier, 1841, p. 94. (*Macrocera*) ♂. FRENCH GUIANA.

Tetralonia cajennensis Smith, 1854, p. 307. WEST INDIES.

californica Smith, see *smithii*; for that of Cresson, see *Tetralonia*.

caliginosa Cresson, 1878a, p. 192. ♀*, ♂. GEORGIA; (Morrison, Ridings).

Smith, 1910, p. 693. Gloucester County, NEW JERSEY; IX; (Fox).

catalinensis. See *intermediella catalinensis*.

carolinensis Dalla Torre, 1896, p. 228. (*Eucera*) New name for *Tetralonia atrifrons* Smith, 1854, p. 308 (not p. 307). ♀. NORTH CAROLINA.

Smith, 1910, p. 693. Camden County, NEW JERSEY; (Fox).

chrysothamni Cockerell, 1905i, p. 524. ♀. Embudo on the Rio Grande, NEW MEXICO; IX; at *Chrysothamnus*. 1906, p. 309: "Upper Sonoran."

civica Cockerell, 1910, p. 258. ♀. Mexico.

cnici Robertson, 1901, p. 230. A new name for the ♂ (not ♀) of *nigripes* Smith, 1854, p. 311; may include the ♀ of *desponsa* Smith, 1854, p. 310 (see Robertson, 1902, p. 49), and is the *desponsa* Robertson, 1897, p. 354. Carlinville, ILLINOIS; at *Monarda fistulosa*.

Grænicher, 1911, p. 247. Randall in Burnett County, Never's Dam and Farmington in Polk County, Hudson in St. Croix County, and Prescott and Maiden Rock in Pierce County, WISCONSIN; VII, VIII. Suggests that these may be *desponsa* Smith.

Robertson, 1914, p. 69. At *Cnicus*.

colliciata Cockerell, 1910, p. 257. ♂. MEXICO; (Deppe).

coloradensis Cresson, 1878a, p. 200. ♀*, ♂. COLORADO; (Ridings, Morrison).

Robertson, 1894, pp. 454–476. Macoupin County, ILLINOIS; at *Lacinaria* ["*Liatris*"] *pycnostachya*, *Silphium laciniatum*, *Helianthus mollis*, *grosseserratus*, and *tuberosus*, and *Cnicus lanceolatus*.

Robertson, 1896, pp. 176–178. Carlinville, ILLINOIS; at *Silphium perfoliatum*, *Heliopsis lavis* and *Rudbeckia laciniata*.

Robertson, 1898a, p. 244. At *Helianthus divaricatus*.

comanche Cresson, 1872, p. 276. ♀*, ♂. TEXAS; (Belfrage, Boll).

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

communis Cresson, 1878a, p. 204. ♀*, ♂. GEORGIA. ILLINOIS

Cockerell, 1906, p. 92. Bill William's Fork, ARIZONA; (Snow).

Smith, 1910, p. 693. Gloucester County, NEW JERSEY; VII.

Cockerell, 1914e, p. 31. Stone Cabin Canyon, Santa Rita Mountains, ARIZONA; at *Thunberia thespesioides*; VIII; (Pierce).

See *kallatramie phenacoides*.

composita. See *lupina composita*.

compta. See *Anthedon*.

comptoides Robertson, 1898, p. 52. ♀, ♂. Carlinville, ILLINOIS.

condigna. See *Florilegus*.

confusa Cresson, 1878a, p. 205. ♀*, ♂. COLORADO; (Ridings, Morrison).

Robertson, 1894, pp. 458–460, 468, 471, 272, and 475. Macoupin County, ILLINOIS; at *Boltonia asteroides*, *Aster novæangliæ* and *paniculatus*, *Rudbeckia triloba*, *Helianthus tuberosus*, *Coreopsis palmata*, and *Helenium autumnale*.

M. ruidosensis Cockerell, 1896b, p. 305. ♂. Ruidoso Creek, NEW MEXICO; 6400–7500 ft.; VII; at *Pentstemon* and (?) *Eustoma*.

Robertson, 1896, pp. 175, 176, 178. Carlinville, ILLINOIS; at *Aster ericoides villosus*, *Silphium perfoliatum*, and *Rudbeckia laciniata*.

Cockerell, 1897c, pp. 20, 24. Santa Fé (7000 ft.) and Dripping Spring in Organ Mountains, NEW MEXICO.

Robertson, 1897, p. 355, makes the ♂ *ruidosensis* Cockerell, 1896b, p. 305, a synonym.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

M. ruidosensis Cockerell, 1901c, p. 43. At *Vicia*. 1901a, p. 130: Beulah and Las Vegas, NEW MEXICO; VII, VIII.

Viereck, 1902, p. 46. At *Erigeron*.

Cockerell, 1906, pp. 92, 309. COLORADO. "Canadian to Upper Sonoran."

Cockerell, 1906d, p. 443. Florissant, Teller County, COLORADO; VII.

Cockerell, 1911, p. 33. CANADA: Meota, Saskatchewan; Macleod; Radisson; Prince Albert; VII; (Willing).

confusiformis Cockerell, 1906c, p. 366. ♀. Fedor, Lee County, TEXAS; V*, IX; (Birkman).

Cockerell, 1914b, p. 409. Goodview, COLORADO; VII; at *Helianthus annuus coronatus*.

Cockerell, 1919c, p. 272. ♂. Gold Hill, COLORADO; 8600 ft.; VII; at *Geranium*.

coreopsis Robertson, 1905, p. 368. ♀. Carlinville, ILLINOIS.

Robertson, 1914, p. 69. At *Coreopsis palmata*.

crenulaticornis. See *Tetralonia*.

dagosa Cockerell, 1909c, p. 128. ♂. Osborn's Ranch, Grand Coulee, WASHINGTON; VII.

densa. See *Diadasia enavata densa*.

denticulata Smith, 1854, p. 311. ♂. United States.

M. senilis Smith, 1854, p. 311. ♀. Mount Pleasant, OHIO.

M. senilis Provancher, 1888, p. 301. Cap Rouge, Ottawa; CANADA; (Guignard).

dentiventris Smith, 1854, p. 312. ♂. GEORGIA.

Provancher, 1888, p. 299. ♂, ♀. Cap Rouge, Ottawa, CANADA; (Guignard).

Robertson, 1894, pp. 463, 467, 469-471, 473-476. Macoupin County, ILLINOIS; at *Silphium integrifolium*, *Rudbeckia hirta*, *Lepachys pinnata*, *Helianthus grosseserratus* and *tuberosus*, *Coreopsis tripteris* and *aristosa*, *Bidens chrysanthemoides*, *Helenium autumnale*, and *Cnicus lanceolatus*.

Robertson, 1896, pp. 176-178. Carlinville, ILLINOIS; at *Silphium perfoliatum*, *Heliopsis laevis*, and *Rudbeckia laciniata*.

Robertson, 1897, p. 355, considers *dentiventris* Provancher, 1888, p. 299, = *pennsylvanica*, but see *trinoodis*; and, 1898, p. 53, says that his *dentiventris* of 1897 = *americana* Lepeletier; but, 1901, p. 230 (see also 1902, p. 49) says that Lepeletier's, 1841, p. 92, description of *Macrocera americana* is too poor to justify its use and he uses *dentiventris*, making *desponsa* Smith a doubtful synonym.

Smith, 1910, p. 693. Gloucester County and Da Costa, NEW JERSEY; VII, VIII.

Viereck, 1916, p. 732. Branford, Westville, and Rockville, CONNECTICUT; VIII; at *Veronica*.

Cockerell, 1917e, p. 212. Falls Church, VIRGINIA; at *Helianthus annuus zonatus*.

See *americana*.

desponsa Smith, 1854, p. 310. ♀. OHIO.

Provancher, 1882, p. 174. St. Fargeau, MONTREAL; (Couper).

Robertson, 1894, pp. 455, 459, 470, 473, 475. Macoupin County, ILLINOIS; at *Solidago canadensis*, *Aster novæangliæ*, *Helianthus grosseserratus*, *Coreopsis aristosa*, and *Cnicus altissimus* (also var. *discolor*) and *lanceolatus*.

Dalla Torre, 1896, p. 231, makes *nigripes* Smith a synonym.

Viereck *et al.*, 1905, p. 320. Corvallis, OREGON; III.

Lovell and Cockerell, 1906, p. 109. Waldoboro, MAINE; VII-IX; at *Carduus odoratus* and *arvensis*, *Pontederia cordata*, *Inula helenium*, and *Solidago*.

Smith, 1910, p. 693. Orange Mountains, Lucaston, and Clementon, New Jersey; IX, X.

Viereck, 1916, p. 732. Colebrook and New Haven, CONNECTICUT; VII, VIII. Makes *cnici* Robertson a synonym.

See *cnici* and *dentiventris*.

desponsiformis Cockerell in Viereck *et al.*, 1905, pp. 319-321. ♀. Corvallis, OREGON; (Cordley).

dilecta. See *Tetralonia*.

diminuta. See *Diadasia*.

donata. See *Tetralonia*.

dubitata Cresson, 1878a, p. 194. ♀*, ♂. Georgia; (Ridings, Morrison).

Cockerell, 1911, p. 34, and 1912d, p. 263, says that *dubitata* is a valid species of *Melissodes*, although the name has been used (e. g. Robertson, 1900, p. 54) as a synonym of *Tetralonia atriventris*.

duplocincta Cockerell, 1905g, p. 103. ♂, ♀. Bill William's Fork, ARIZONA; VIII; (Snow).

edwardsii. See *Tetralonia*.

enavata. See *Diadasia*.

epicharina Cockerell, 1905g, p. 99. ♀. Oak Creek Canyon, ARIZONA; 6000 ft.; VII; (Snow).

exquisita. See *Xenoglossa fulviventris*.

festonata Provancher, 1888, p. 300. ♀, ♂. Cap Rouge, Ottawa, CANADA.

fimbriata Cresson, 1878a, p. 203. ♀*, ♂. TEXAS; (Belfrage).

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Smith, 1910, p. 693. Cape May, NEW JERSEY; VI; (Fox).

flaveriæ. See *texana flaveriæ*.

floris Cockerell, 1896a, p. 290. ♂, ♀. San Rafael, Vera Cruz, MEXICO; III; at *Bidens*; (Townsend).

Cockerell, 1899b, p. 13. Lower part of Rio Nautla, MEXICO.

foxi Crawford, 1915, p. 577. ♀*, ♂. Portland, JAMAICA.

Melissodes trifasciata and *mimica* of Fox, 1891, p. 347. Port Antonio and Kingston, JAMAICA.

frater. See *Tetralonia*.

fremontii Cockerell, 1907c, p. 268. ♂. Florissant, COLORADO; VII; at *Geranium fremontii*; (Rohwer).

fulvitaris. See *Tetralonia*.

fulvohirta. See *Tetralonia*.

galvestonensis Cockerell, 1905f, p. 181. ♀, ♂. Galveston, TEXAS; V; (Snow).

georgica Cresson, 1878a, p. 200. ♂. GEORGIA; (Morrison).

gilensis Cockerell, 1896b, p. 306. ♀, ♂. West Fork of Gila River* (about 7000 ft.) and La Tenaja (near Santa Fé), NEW MEXICO; VII; (Townsend, Boyle).

Cockerell, 1897c, p. 24. Dripping Springs, Organ Mountains, NEW MEXICO.

Cockerell, 1901a, p. 130, and 1901c, p. 40. Las Vegas, NEW MEXICO; VII; at *Cleome serrulata* and *Sidalcea neomexicana*; (Porter).

Cockerell, 1905, p. 103. San Pedro, CALIFORNIA; VII.

Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VIII; (Snow).

Cockerell, 1906, pp. 92, 309. COLORADO. Magdalena Mountains, NEW MEXICO; (Snow). "Upper and Lower Sonoran."

Cockerell, 1907, p. 397. Cloudercroft, NEW MEXICO; VI; (Viereck).

glenwoodensis Cockerell, 1905i, p. 522. ♀. Glenwood Springs, COLORADO; IX; (Gillette).

Cockerell, 1906, pp. 107, 309. Maxwell City, NEW MEXICO; IX; at *Grindelia*; (Mize). Related to *Florilegus condignus*. "Upper Sonoran."

grandissima Cockerell, 1905c, p. 334. ♀. Fedor, Lee County, TEXAS; (Birkman). 1906c, p. 361: ♂.

grindeliæ Cockerell, 1898a, pp. 66, 67. ♂, ♀. Santa Fé* and Tuerto Mountain (8875 ft.), NEW MEXICO; VII, VIII; at *Grindelia*, *Lepachys*, and *Rudbeckia*. 1899d, p. 256: Las Vegas, NEW MEXICO.

Viereck, 1906, p. 238. Oak Creek Canyon, ARIZONA; VII, VIII; (Snow).

Cockerell, 1901a, p. 130, and 1901c, p. 40. Las Vegas Hot Springs, NEW MEXICO; VII, VIII; at *Cleome serrulata*, *Senecio douglasii*, *Helianthus annuus*, *Verbena macdougalii*, *Lepachys columnaris* and *tagetes*, and *Verbesina encelioides*; (Porter).

Cockerell, 1905, p. 103. La Jolla, CALIFORNIA; VIII.

Cockerell, 1906, pp. 92, 309. Organ Mountains and Pecos, NEW MEXICO; VIII; at *Sphaeralcea fendleri*. "Canadian to Lower Sonoran." "Not quite typ cal" specimens from Oak Creek Canyon, ARIZONA; 6000 ft.; (Snow).

Cockerell, 1910, p. 257. MEXICO; (Deppe).

helensæ Cockerell, 1906c, p. 365. The *M. humilior* var. *a* Cockerell, 1903, p. 447. Las Cruces, NEW MEXICO; VIII; (Townsend). 1906, p. 310: "Middle Sonoran."

helianthelli Cockerell, 1905i, p. 525. ♀. Mesilla, NEW MEXICO; VI; at *Helianthus ciliaris*. 1906, p. 310: "Middle Sonoran."

helianthophila Cockerell, 1914d, p. 361. ♂. Boulder, COLORADO; VI; at *Helianthus lenticularis*.

herricki Cockerell, 1905g, p. 98. ♂, ♀. NEW MEXICO; (Snow).

hewetti Cockerell, 1905i, p. 527. ♀. Santa Fé, NEW MEXICO; VIII; at *Cleome serrulata*. 1906, p. 309: "Transition" zone.

hexacantha Cockerell, 1905g, p. 100. ♂. ARIZONA; VIII; (Snow). Varieties at Oak Creek Canyon, ARIZONA; 6000 ft.

hirsuta Smith, 1879, p. 116. ♂. Oaxaca, MEXICO.

Euclera oajacana Dalla Torre, 1896, p. 242. New name.

Cockerell, 1905e, p. 328. Notes on type.

hitei Cockerell, 1908, p. 331. (*M. martini hitei*) ♀. Pueblo, COLORADO; VIII; (Hite).

Cockerell, 1909c, p. 129. ♀. Plano (about 17 miles north of Dallas), TEXAS; X; (Tucker).

honesta. See *Tetralonia belfragii*.

hortivagans Cockerell, 1905f, p. 180. ♂. Garden City, KANSAS; VIII; (Menke). P. 181: var. *a*; Morton County, KANSAS; 3200 ft.; (Snow).

Cockerell, 1906, p. 107. Keatchie, LOUISIANA; VI; (Newell). Makes *variabilis* Robertson a synonym.

Cockerell, 1906c, p. 360. Fedor, Lee County, TEXAS; V, VI; (Birkman). A partial gynandromorph.

humilior Cockerell, 1903, p. 447. ♀. Organ* (5100 ft.) and Las Cruces, NEW MEXICO; VIII. 1906, p. 309: "Upper Sonoran."

Cockerell, 1914a, p. 286. Rito de Los Frijoles, NEW MEXICO; VIII. See *helenæ*.

humilior catalinensis Cockerell, 1995, p. 102. (*M. intermediella catalinensis*) ♀. Catalina Island, CALIFORNIA; (Davidson).

hymenoxidis Cockerell, 1906d, p. 443. ♀. Florissant, Teller County. COLORADO; VII; at *Hymenoxys ligulæflora* and *Chrysopsis*.

Cockerell, 1915, p. 269. Ward, COLORADO; 9200 ft.; VIII.

Cockerell, 1918, p. 160. Tolland, COLORADO; VIII.

illata Lovell and Cockerell, 1906, p. 110. ♀, ♂. Waldoboro, MAINE; VII, VIII; at *Epilobium angustifolium*, *Inula helenium*, and *Solidago*.

illinoensis Robertson, 1895, p. 126. ♀, ♂. Carlinville, ILLINOIS.

Robertson, 1899, p. 37. At *Lepachys pinnata*.

Robertson, 1914, p. 70. At *Helianthoides*.

insularis Crawford, 1914, p. 132. ♂. DOMINICA; (Foote).

intermedia Cresson, 1872, p. 278. ♀. TEXAS; (Belfrage).

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

See *intermediella*.

intermediella Cockerell, 1905, p. 102. ♀. Mesilla Valley, NEW MEXICO (*intermedia* Cockerell, 1898a, p. 67). Los Angeles, CALIFORNIA. 1906, pp. 92, 310: "Middle Sonoran"; ARIZONA.

intermediella catalinensis. See *humilior catalinensis*.

intorta Cresson, 1872, p. 278. ♂. TEXAS; (Belfrage).

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

intrudens. See *Tetralonia*.

kallstroëmiæ Cockerell, 1905*h*, p. 216. ♂. Mesilla Park, NEW MEXICO VII; at *Kallstroëmiæ*. 1906, p. 310: "Middle Sonoran."

kallstroëmiæ phenacoides Cockerell, 1905*h*, p. 217. ♂. Las Cruces, NEW MEXICO; VIII.

M. communis Cockerell, 1898*a*, p. 66. Mesilla Valley, NEW MEXICO.

Cockerell, 1906, pp. 92, 310. "Middle Sonoran." *M. communis*: Bill William's Fork, ARIZONA; (Snow.)

kelloggi Cockerell, 1919*b*, p. 293. ♂. Long's Peak Inn, COLORADO; VII.

labiatarum Cockerell, 1896*a*, p. 291. ♂. San Rafael and Paso de Telaya, Vera Cruz, MEXICO; III, IV; at a labiate; (Townsend).

Cockerell, 1899*b*, p. 13. Lower part of Rio Nautla, MEXICO.

lanierii. See *Florilegus*.

lata. See *Tetralonia*.

lepida. See *Tetralonia*.

lœna Cockerell, 1909*d*, p. 148. ♂. Lee County, TEXAS; XI; (Birkman).

lupina Cresson, 1878*a*, p. 210. CALIFORNIA; (H. Edwards).

Cockerell, 1906, pp. 31, 309. Doubts its distinctness from *agilis*. "Upper Sonoran."

Cockerell, 1909*e*, p. 305. Colorado Springs, COLORADO; VIII; (Tucker). Raton, NEW MEXICO. Notes on variation.

lupina composita Tucker, 1909, p. 281. ♂. Colorado Springs, COLORADO; VIII.

luteicornis. See *Martinella*.

machaeranthæ Cockerell, 1904*a*, p. 21. ♂. White Sands, NEW MEXICO; and Buckeye, ARIZONA; IX; at *Machaeranthæ* and *Cucurbita palmata*. (?) ♀; Phoenix, ARIZONA; X; at *Helianthus annuus*. 1906, p. 310: "Middle and Lower Sonoran."

manipularis Smith, 1854, p. 240. ♂. GEORGIA.

Cockerell, 1905*e*, p. 329. Notes on type.

Cockerell, 1907*e*, p. 127. Falls Church, VIRGINIA; IX; at *Eupatorium*; (Banks).

marginella. See *Entechnia euglossoides marginella*.

martini Cockerell, 1905*i*, p. 526. ♀. Gallinas River at Las Valles, NEW MEXICO; VIII.

Cockerell, 1906, pp. 93, 309. At *Petalostemon oligophyllus*. "Upper Sonoran."

martini hitei. See *hitei*.

martinicensis Cockerell, 1917*b*, p. 303. ♂. MARTINIQUE; VII; (Busek).

masuca Cockerell, 1909*d*, p. 148. ♂. Fedor, Lee County, TEXAS; VI; (Birkman).

Cockerell, 1917*a*, p. 191. Point Isabel and San Benito, TEXAS; at cactus, *Phlox*, and *Parkinsonia aculeata*; (W. P. Cockerell).

maura Cresson, 1865, p. 188. ♀. CUBA.

megacerata Cockerell, 1906*c*, p. 362. ♂. Fedor, Lee County, TEXAS; X; (Birkman).

melandri Cockerell, 1906, p. 109. ♀. Fedor, Lee County, TEXAS; X; (Birkman).

melanosoma, Cockerell, 1905*c*, p. 266. ♂. Fedor, Lee County, TEXAS; V; (Birkman).

menuacha Cresson, 1868, p. 388. (*menuachus*) ♂. NEW MEXICO* and COLORADO; (Lewis).

Cresson, 1872, p. 277. TEXAS; (Belfrage, Boll).

Cresson, 1876, p. 209. Boulder, COLORADO; (Putnam).

Uhler, 1877, p. 783. Canyon City, COLORADO; VIII.

Cockerell, 1893, p. 338. West Cliff, Custer County, COLORADO; V.

(?) Fox, 1893, p. 118. Lower California, MEXICO; (Eisen).

Townsend, 1896, p. 139. Las Cruces, NEW MEXICO.

Cockerell, 1897*d*, p. 138. Santa Fé (7000 ft.), La Junta, and Fremont County, New Mexico; VIII; at *Argemone* (1897*f*, p. 79, sleeping in closed flowers of *A. platyceras*) and *Grindelia*. Not in Mesilla Valley, New Mexico.

Cockerell, 1898*f*, p. 313. Rinconada, NEW MEXICO; at *Bigelovia* [*Chrysanthamnus*].

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Smith, 1900, p. 693. Camden County, NEW JERSEY; (Fox).

Cockerell, 1903*b*, p. 77. CALIFORNIA.

Viereck *et al.*, 1905, p. 320. OREGON.

Cockerell, 1906, pp. 92, 309. Denver, COLORADO; (Johnson). Las Vegas and Raton, NEW MEXICO. "Transition and Upper Sonoran."

Cockerell, 1906*d*, p. 443. Florissant, Teller County, COLORADO; VII; at *Sidalcea neomexicana*.

Tucker, 1909, p. 282. Colorado Springs, COLORADO; VII.

Cockerell, 1912*d*, p. 271: "Bertoni and Schrottky (1910) state that they have received it [*nigroaenea* Smith, 1854] from Texas, labelled *M. menuacha*. A female *nigroaenea* received from Schrottky has the facial quadrangle broader and shorter than in *menuacha*. It is from San Juan, Argentina." See *nigroaenea*.

menuacha semilupina Cockerell, 1905, p. 29. ♂. Los Angeles, CALIFORNIA; (Davidson).

menuacha submenuacha Cockerell, 1897*d*, p. 137. ♂. Las Cruces and College Farm, NEW MEXICO; IX; at *Helianthus annuus* and *Verbesina encelioides*.

Cockerell, 1898a, pp. 66, 73. Albuquerque and Mesilla Valley, NEW MEXICO; IX. 1906, p. 309: "Upper to Middle Sonoran."

menuacha vernonensis Viereck *et al.*, 1905, pp. 319, 320. ♀, ♂. Vernon, BRITISH COLUMBIA; VIII; (Harvey).

M. vernonensis Cockerell, 1906, p. 78.

microsticta Cockerell, in Viereck *et al.*, 1905, pp. 319-321. ♂. Vancouver Island, BRITISH COLUMBIA.

Cockerell, 1906, p. 113. COLORADO.

mimica Cresson, 1869, p. 298. (*mimicus*) ♂. CUBA.

Ashmead, 1900, p. 210. GRENADA and ST. VINCENT.

See *foxi*.

mizeæ Cockerell, 1905i, p. 522. ♀. Las Vegas, NEW MEXICO; VIII; at *Grindelia inornata*; (Mize). "Upper Austral zone." 1906, p. 309: "Upper Sonoran."

Cockerell, 1912b, p. 448. Abbott Ranch, Rito de los Frijoles, NEW MEXICO; VIII.

modesta. See *Thygater*.

montana Cresson, 1878a, p. 202. ♀*, ♂. COLORADO*, (Ridings). NEW MEXICO; (Lewis).

Townsend, 1896, p. 139. Las Cruces, NEW MEXICO.

Cockerell, 1896b, p. 308. West Fork of the Gila, NEW MEXICO; about 7000 ft.; VII; (Townsend).

Cockerell, 1897c, pp. 21, 24, 28. Dripping Springs (Organ Mountains) and Mesilla Valley (3800 ft.), NEW MEXICO.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Viereck, 1903b, p. 728. San Pedro and La Jolla, CALIFORNIA; VII, VIII; (Cockerell).

Cockerell, 1906, pp. 92, 309. Oak Creek Canyon, ARIZONA; (Snow). "Upper Sonoran."

montezuma. See *Thygater*.

morosa Cresson, 1878a, p. 193. ♀. MEXICO; (Sumichrast).

morrilli. See *bimaculata morrilli*.

mysops Cockerell, 1905d, p. 146. ♂, ♀. Maybell* and Virginia Dale, COLORADO; VIII; at thistle; (Johnson, Bishopp).

Cockerell, 1907c, p. 269. Florissant, COLORADO; VII; at *Carduus aculeolens*.

Cockerell, 1910d, p. 128. Near Axial, COLORADO; *Rudbeckia ampla*, (Robbins).

nevadensis Cresson, 1874, p. 102, and 1875, p. 726 (not 1879, p. 209; see *Tetralonia intrudens*). ♂. NEVADA; (Yarrow).

Cockerell, 1897c, p. 28. Mesilla Valley, NEW MEXICO; 3800 ft.

nigra. See *bimaculata*.

nigricornis. See *Tetralonia*.

nigrifrons. See *Diadasia*.

nigripes Smith, 1854, p. 311. ♀. United States. For his ♂, see *cnici*.

Provancher, 1888, p. 300. Cap Rouge, Ottawa, CANADA.

Synhalonia nigripes Robertson, 1895, p. 126.

Dalla Torre, 1896, p. 231, makes it a synonym of *desponsa* Smith.

Robertson, 1900, p. 53, considers that Smith's, 1854, p. 311, ♀ (not ♂) *Emphor bombiformis* belongs here.

Smith, 1910, p. 093. Newark, New Brunswick, Jamesburg, Lahaway, Prospertown, Riverton, and Westville, NEW JERSEY; V, VI.

nigripes. See *Emphor*.

nigrosænea Smith, 1854, p. 305. (*Tetralonia*) ♀. BRAZIL.

Cockerell, 1912d, p. 271. San Juan, ARGENTINA. See *menuacha*.

Tetralonia nigrosænea Friese, 1916, p. 295. San José, COSTA RICA; (Schmidt).

nigrosignata Cockerell, 1905g, p. 101. ♀. Oak Creek Canyon, ARIZONA; 6000 ft.; VIII; (Snow).

Cockerell, 1906, pp. 109, 309. San Ignacio, NEW MEXICO; VIII; (W. P. Cockerell). "Upper Sonoran."

nigrosignata pallidesignata Cockerell, 1905f, p. 180. ♀. Oak Creek Canyon, ARIZONA; 6000 ft.; VIII; (Snow).

nivea Robertson, 1895, p. 127. ♀. Carlinville, ILLINOIS. 1896, p. 175: at *Aster ericoides villosus*. 1897, p. 354, describes the ♂. 1898, p. 53, suggests that it may be *snowii*.

Robertson, 1898a, pp. 230, 244. At *Lespedeza reticulata* and *Helianthus divaricatus*.

Cockerell, 1907e, p. 128. Falls Church, VIRGINIA; IX; (Banks).

oajacena. See *hirsuta*.

obliqua Say, 1837, p. 403. (*Macrocera*) ♂. INDIANA.

Cresson, 1872, p. 275. TEXAS; (Belfrage, Boll, Heiligbrodt).

Robertson, 1891a, p. 573. At *Asclepias cornuti*.

Robertson, 1894, pp. 451-476. Macoupin County, ILLINOIS; at *Vernonia fasciculata* (printed *noveboracensis* but changed by the author in copies sent out), *Lacinaria* ["*Liatris*"] *pycnostachya*, *Solidago missouriensis*, *Silphium integrifolium*, *Echinacea purpurea* (tried in vain to collect pollen), *Rudbeckia hirta* and *triloba*, *Lepachys pinnata*, *Helianthus mollis*, *grosseserratus*, *strumosus*, and *tuberosus*, *Verbesina helianthoides*, *Coreopsis tripteris*, and *Cnicus altissimus discolor* and *lanceolatus*.

Robertson, 1896, pp. 176-178. Carlinville, ILLINOIS; at *Silphium perfoliatum*, *Heliopsis laevis* and *Rudbeckia laciniata*.

Townsend, 1896, p. 140. Las Cruces, NEW MEXICO.

Cockerell, 1896, p. 305. Santa Fé, NEW MEXICO; at *Cleome serrulata*.

Cockerell, 1897c, p. 28. Mesilla Valley, NEW MEXICO; 3800 ft.

- Robertson, 1898a, p. 244. At *Helianthus divaricatus*.
 Cockerell, 1899, p. 157. Mesilla Valley, NEW MEXICO; VII; (Barber).
 Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).
 Birkman, 1899, p. 245. Fedor, Lee County, TEXAS; V; (See Cockerell, 1905c, p. 335).
 Cockerell, 1903b, p. 77. CALIFORNIA.
 Cockerell, 1904, p. 8. Pecos, San Miguel County, NEW MEXICO; VIII.
 Robertson, 1905, p. 368. Carlinville, ILLINOIS.
 Cockerell, 1906, p. 309. Las Vegas, Pecos, and Raton, NEW MEXICO "Transition to Middle Sonoran."
 Tucker, 1909, p. 278. Lawrence and Wichita, KANSAS; VII, VIII.
 Smith, 1910, p. 693. Camden County, NEW JERSEY.
 Grænicher, 1911, p. 247. Hudson in St. Croix County, and Prescott and Maiden Rock in Pierce County, WISCONSIN; VII, VIII; at *Lepachys pin-nata*, *Rudbeckia hirta*, and *R. laciniata*.
 Cockerell, 1911, p. 390. Sterling, COLORADO; VIII; at *Helianthus*.
 Cockerell, 1914b, p. 411. Clarendon, TEXAS; VIII; (Jones).

olivacea. See *Dasiapis*.

opuntiella Cockerell, 1911, p. 131. ♂*, ♀. Brownsville*, Hondo, and Cotulla, TEXAS; III-IV; at *Opuntia lindheimeri*; (Jones, Pratt, Mitchell, Crawford).

otomita Cresson, 1878a, p. 209. ♂. MEXICO; (Sumichrast).

pallida Robertson, 1895, p. 127. ♀. Carlinville, ILLINOIS.

pallidicincta Cockerell, 1896b, p. 306. ♀. West Fork at Gila* River, Santa Fé, and Watrons, NEW MEXICO; VI, VII; at alfalfa.

Cockerell, 1897c, p. 22. Pinos Altos (at hollyhock) and, in Organ Mountains, Dripping Springs and Soledad Canyon, NEW MEXICO.

Cockerell, 1901a, p. 130, and 1901c, pp. 40, 43. Las Vegas and Romersville, NEW MEXICO; VII; at *Cleome serrulata*, *Trifolium repens*, *Malvastrum dissectum*, *Sidulcea neomexicana*, *Verbena macdougalii*, *Sphaeralcea lobata*, *Asclepias verticillata*, and *Lycium vulgare*; (Stern).

Cockerell, 1904, p. 8. Pecos, San Miguel County, NEW MEXICO; VI; asleep in *Pentstemon* flowers in rainy weather; (Grabham).

Cockerell, 1906, pp. 92, 109, 309. Bill William's Fork and Oak Creek Canyon, ARIZONA; (Snow.) Boulder, COLORADO; VII; at *Opuntia*; (W. P. Cockerell). Magdalena Mountains (Snow) and Gibson (Gohrman), NEW MEXICO. Clark County, KANSAS; 1962 ft.; (Snow). "Transition to Upper Sonoran."

Cockerell, 1906d, p. 443. Florissant and east of Lake George, COLORADO; VI, VII; at *Iris missouriensis*, *Crepis runcinata*, and *Senecio*.

Cockerell, 1907, p. 397. Alamogordo, Cloudcroft, and Highrolls, NEW MEXICO; V, VI; (Viereck).

See *tristis*.

pallidisignata. See *nigrosignata pallidisignata*.

palustris. See *Florilegus condigna*.

parosela Cockerell, 1905*i*, p. 528. ♂. Mesilla, NEW MEXICO; VII; at *Parosela scoparia*. 1906, p. 310: "Middle Sonoran."

pecosella Cockerell, 1905*f*, p. 179. ♀. Pecos, NEW MEXICO; (W. P. Cockerell). 1906, p. 309: "Upper Sonoran."

pecosella verbesinarum. See *Xenoglossodes excurrans*.

pennsylvanica Lepeletier, 1841, p. 97. (*Macrocera*) ♂. PENNSYLVANIA.

Smith, 1854, p. 312.

Cresson, 1872, p. 280. TEXAS; (Belfrage).

Uhler, 1877, p. 783. Canyon City, COLORADO; VIII.

Robertson, 1897, p. 355, makes *dentiventris* Provancher, 1888, p. 299, a synonym, but see *trinodia*.

Robertson, 1898*a*, p. 244. Carlinville (?), ILLINOIS; at *Helianthus divaricatus*.

Smith, 1910, p. 693. NEW JERSEY; (Beutenmüller).

pernigra Cockerell, 1896*a*, p. 289. ♂. San Rafael and Paso de Telaya, Vera Cruz, MEXICO; III; at *Ipomæa*; (Townsend).

Cockerell, 1899*b*, p. 13. Lower part of Rio Nautla, MEXICO.

perplexa Cresson, 1878*a*, p. 206. ♀*, ♂. Georgia*; (Morrison). TEXAS; (Belfrage).

Robertson, 1891*a*, p. 582, 596, 597. Carlinville, ILLINOIS; at *Datura tatula*, *Gerardia purpurea*, and *tenuifolia*.

Robertson, 1894, pp. 451-475. Macoupin County, ILLINOIS; at *Vernonia fasciculata* (printed *noveboracensis* and changed by author in copies sent out), *Solidago missouriensis canadensis* and *lanceolata*, *Asler novæangliæ* and *paniculatus*, *Rudbeckia hirta* and *triloba*, *Lepachys pinnata*, *Helianthus grosseserratus*, *Coreopsis aristosa*, *Bidens chrysanthemoides*, and *Helenium autumnale*.

Robertson, 1896, pp. 176, 177. Carlinville, ILLINOIS; at *Silphium perfoliatum* and *Heliopsis laevis*.

Cockerell, 1899*c*, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

Viereck, 1903*a*, p. 119. College Park, MARYLAND; IX.

Smith, 1910, p. 693. Newark, Riverton, Manumuskin, and Belleplain, NEW JERSEY VIII, IX.

Viereck, 1916, p. 732. East Hartford, Hartford, and Salisbury, CONNECTICUT; VIII.

personatella Cockerell, 1901, p. 297. ♂. La Jolla, San Diego County, CALIFORNIA; VIII.

petalostemonis Robertson, 1900, p. 53. Carlinville, ILLINOIS.

petulca Cresson, 1878*a*, p. 201. ♀. GEORGIA; (Morrison).

Cockerell, 1906, p. 92. Fedor, Lee County, TEXAS; V; (Birkman).

petulca suffusa Cresson, 1878*a*, p. 203. (*M. suffusa*) ♀*, ♂. TEXAS; (Belfrage, Heiligbrodt).

M. suffusa Fox, 1893, pp. 21, 118. San José del Cabo and Mesa Verde, Lower California, MEXICO; X; (Eisen).

M. suffusa Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Cockerell, 1906, p. 92. Flagstaff, ARIZONA; VIII; (Snow).

Cockerell, 1906c, p. 360. V, VI.

M. suffusa Cockerell 1914a, p. 286, and 1914b, p. 414 (♂ var.). Falfurrias; TEXAS; V; at *Helianthus*; (Morgan).

petulciformis Cockerell, 1906c, p. 364. ♀. Fedor, Lee County; TEXAS; VI; (Birkman).

phenacoides. See *kallstræmia phenacoides*.

philadelphica Lepeletier, 1841, p. 110. (*Macrocera*) ♂. PENNSYLVANIA.

Smith, 1854, p. 312.

pimella Cockerell, 1906c, p. 363. ♂. ARIZONA.

pinguis Cresson, 1878a, p. 216. ♀*, ♂. MEXICO; (Sumichrast).

Cockerell, 1897b, p. 157. San Rafael and Paso de Telaya, Vera Cruz, MEXICO; III, IV; at *Sida*; (Townsend). New description of ♀.

Cockerell, 1899b, p. 13. Lower part of Rio Nautla, MEXICO.

pinguis velutinella Cockerell, 1897b, p. 158. ♂. San Rafael, Vera Cruz, MEXICO; III; at *Sida*; (Townsend).

prælauda Cockerell, 1905g, p. 102. ♂. Oak Creek Canyon, Arizona; 9000 ft.; (Snow).

pruinosa. See *Xenoglossa*.

pullata Cresson, 1865, p. 189. ♀*, ♂. CUBA.

pygmaea. See *Exomalopsis*.

raphaelis Cockerell, 1896a, p. 292. ♂. San Rafael, Vera Cruz, MEXICO; III; at *Ipomæa*; (Townsend).

Cockerell, 1899b, p. 13. Lower part of Rio Nautla, MEXICO.

Cockerell, 1912b, p. 28. Quirigua, GUATEMALA, II; at *Ipomæa sidæfolia*; (W. P. Cockerell).

rivalis Cresson, 1872, p. 277. ♂. TEXAS; (Belfrage, Boll.).

robustior Cockerell, 1915b, p. 482. ♀, ♂. Berkeley and (♂) Los Angeles, CALIFORNIA; VIII; at *Helianthus annuus* and *lenticularis*.

rubricata. See *Thygater*.

rufodentata Smith, 1854, p. 314. ♂. ST. VINCENT; (Smith).

ruidosensis. See *confusa*.

rustica Say, 1837, p. 406. (*Macrocera*) ♂, ♀. INDIANA.

Smith, 1854, p. 309.

Patton, 1879, p. 472. Cites this species as the type of *Melissodes*.

Provancher, 1888, p. 300. Ottawa, CANADA; (Guignard).

Evans, 1896, p. 13. Sudbury, ONTARIO.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Viereck, 1903a, p. 119. College Park, MARYLAND; IX.

Smith, 1910, p. 693. Newark, Trenton, and Westville, NEW JERSEY; IX.

"Mr. Viereck suggests that this may be the same as *simillima* Robertson."

Grænicher, 1911, p. 247. St. Croix Dam in Douglas County; mouths of Nemakagon and Yellow Rivers, Swiss, and Randall in Burnett County; Farmington in Polk County; Hudson in St. Croix County; and Maiden Rock in Pierce County; WISCONSIN; VII, VIII.

Viereck, 1916, p. 732. Rockville and Stafford, CONNECTICUT; VIII; at *Solidago*. Makes *simillima* Robertson a synonym.

sandiarum. See *atrifera sandiarum*.

saponellus Cockerell, 1908a, p. 234. ♀. Soap Lake, Grand Coulee, WASHINGTON; VI; (Melander). Suggests that it may be *Xenoglossodes*.

semiagilis Cockerell, 1906c, p. 364. (*M. agilis semiagilis*) ♂. Fedor, Lee County, TEXAS; V*, X.

Cockerell, 1914b, p. 413. ♀. Quanah*, INDIAN TERRITORY [Texas ?]; VI; at *Helianthus*; (Mitchell). Dallas, TEXAS; IX; (Bishopp).

Cockerell, 1919c, p. 27. ♂. Boulder, COLORADO; X; at *Helenium*.

semilupina. See *menuacha semilupina*.

semitristis Cockerell, 1905g, p. 102. ♂. Oak Creek Canyon, ARIZONA; 6000 ft.; VII; (Snow).

senilis. See *denticulata*.

simillima Robertson, 1897, p. 355. Carlinville, ILLINOIS.

Robertson, 1898a, p. 244. At *Helianthus divaricatus*.

Lovell and Cockerell, 1906, p. 111. Waldoboro, MAINE; VIII, IX; at *Carduus arvensis* and *Solidago*.

Robertson, 1914, p. 70. At *Helianthoideæ* and *Asteroideæ*.

See *rustica*.

smithii Dalla Torre, 1896, p. 247. (*Eucera*) New name for *Melissodes californica* Smith, 1879, p. 114, not Cresson. ♀, ♂. CALIFORNIA.

Cockerell, 1905e, p. 328. Notes on type.

snowii Cresson, 1878a, p. 211. ♂. COLORADO; (Snow).

Robertson, 1898, p. 53. Suggests that *nivea* may be a synonym.

M. agilis snowii Tucker, 1909, p. 278. Denver, COLORADO; VIII.

speciosa. See *Tetralonia*.

sphaeralces Cockerell, 1896b, p. 304. ♂. Santa Fé, NEW MEXICO; VII; at *Sphaeralcea angustifolia*.

Cockerell, 1904, p. 8. Pecos, San Miguel County, NEW MEXICO; VIII; at *Sphaeralcea fendleri*; nest. 1906, p. 309: "Transition to Upper Sonoran."

spissa Cresson, 1872, p. 280. ♀. TEXAS; (Belfrage).

stearnsi. See *Exomalopsis*.

strenua. See *Xenoglossa*.

stretchii. See *Tetralonia*.

suavis Cresson, 1878a, p. 210. ♀. COLORADO; (Morrison).

subagilis. See *agilis subagilis*.

submenuacha. See *menuacha submenuacha*.

suffusa. See *petulca suffusa*.

sumichrasti. See *Diadasia*.

tenuitarsis Cockerell, 1905*g*, p. 99. ♂. ARIZONA; VIII; (Snow).

tapaneca Cresson, 1878*a*, p. 211. ♀*, ♂. MEXICO; (Sumichrast).

tapaneca aschenborniana Cockerell, 1912*b*, p. 28. ♂. Gualan, GUATEMALA; at *Vernonia aschenborniana*; (W. P. Cockerell).

tepida Cresson, 1878*a*, p. 210. ♀. NEVADA; (Edwards).

Cockerell, 1903*b*, p. 77. CALIFORNIA.

texana Cresson, 1872, p. 276. ♀, ♂*. TEXAS; (Belfrage, Boll).

Uhler, 1877, p. 783. Colorado Springs, COLORADO; VIII.

Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

texana flaveriæ Cockerell, 1906, pp. 108, 310. ♀. Roswell, NEW MEXICO; VIII, IX; at *Flaveria angustifolia*. "Middle Sonoran."

thelypodii Cockerell, 1905*i*, p. 527. ♀. La Cueva, Organ Mountains, NEW MEXICO; about 5300 ft.; at *Thelypodium linearifolium*; IX; (Townsend).

Cockerell, 1906, pp. 107, 309. Las Cruces, NEW MEXICO; VIII; at *Ipomæa mexicana*. "Upper to Middle Sonoran."

thurberiæ Cockerell, 1914*e*, p. 31. ♀. Stone Cabin Canyon, Santa Rita Mountains, ARIZONA; at *Thurberia thespesioides*; VIII; (Pierce).

toluca. See *Entechnia*.

townsendi Cockerell, 1896*b*, p. 304. ♂. La Cruces, NEW MEXICO; VIII; (Townsend).

Cockerell, 1897*c*, p. 28. Mesilla Valley, NEW MEXICO; 3800 ft. 1906, p. 310: "Middle Sonoran."

trifasciata Cresson, 1878*a*, p. 208. ♀. PORTO RICO; (Klug).

See *foxi*.

trifasciatella Ashmead, 1900, p. 210. ♀. Kingstown, ST. VINCENT.

trinodis Robertson, 1901, p. 231. A new name for *pennsylvanica* Robertson, 1897, p. 355. Carlinville, ILLINOIS.

Smith, 1910, p. 693. Chester, NEW JERSEY; IX.

Gränicher, 1911, p. 247. Mouth of Yellow River and Randall in Burnett County, Farmington in Polk County, and Hudson in St. Croix County, WISCONSIN; VII, VIII.

tristis Cockerell, 1894, p. 234. ♂. Las Cruces, NEW MEXICO; VIII.

Cockerell, 1896*b*, p. 304. ♂. Mesilla Valley and San Marcial, NEW MEXICO.

Cockerell, 1897*c*, p. 24. Dripping Springs, Organ Mountains, NEW MEXICO.

Cockerell, 1899, p. 156. Mescalero Indian Agency on Tularosa Creek, NEW MEXICO; VII; (Barber).

Cockerell, 1900b, p. 218. Juarez, MEXICO; X; at *Ipomoea mexicana*.

Cockerell, 1901c, p. 40. Las Vegas, NEW MEXICO; VII; at *Cleome serrulata*. Probably the ♂ of *pallidicincta*.

Cockerell, 1906, pp. 92, 309. Oak Creek Canyon, ARIZONA; (Snow). Magdalena Mountains (Snow) and Raton, NEW MEXICO. "Upper to Middle Sonoran."

Cockerell, 1907, p. 397. Alamogordo and Highrolls, NEW MEXICO; V. VI; (Viereck).

tristis malvina Cockerell, 1902a, p. 177. ♂. Cerro Chilicote, Chihuahua, MEXICO; III; at (?) *Sidalcea*.

tuckeri Cockerell, 1909c, p. 129. ♀. Plano (about 17 miles N. of Dallas), TEXAS; X; (Tucker).

ursina. See *Diadasia enavata*.

variabilis Robertson, 1905, p. 368. ♀, ♂. Carlinville, ILLINOIS.

See *horitvagans*.

velutinella. See *pinguis velutinella*.

verbesinarum. See *pecosella verbesinarum*.

vernonensis. See *menuacha vernonensis*.

vernonis Robertson, 1902, p. 323. ♀, ♂. Carlinville (?), ILLINOIS.

Cockerell, 1909, p. 26. Malcolm, NEBRASKA; IX; (Birkman).

Grænicher, 1911, p. 247. Hudson in St. Croix County, and Prescott and Maiden Rock in Pierce County, WISCONSIN; VII, VIII; at *Vernonia*.

vernoniana Robertson, 1905, p. 368. ♀, ♂. Carlinville, ILLINOIS.

Robertson, 1914, p. 69. At *Veronnia*.

wheeleri Cockerell, 1906, p. 111. ♀. Fedor, Lee County, TEXAS; V; (Birkman). 1906c, p. 367: ♂.

wickhami Cockerell, 1906, p. 112. ♀. Fedor, Lee County, TEXAS; V; (Birkman).

xanthopteralis Cockerell, 1906c, p. 362. ♂. Fedor, TEXAS; V; (Birkman).

Peponapis

See *Xenoglossa*.

Synhalonia

Emended to *Synalonia* by Robertson, 1905, p. 365. See *Tetralonia*.

TETRALONIA Spinola, 1838, p. 538

As indicated elsewhere, we are using in this list the names most in use at present but it is not out of place to point out certain difficulties.

Spinola proposed the above name in the first paragraph of his description of *basizona*, substituting it for Latreille's, 1825, p. 464, *Macrocera*, preoccupied by Meigen in Diptera. In the last paragraph of his discussion of *basizona* he raises the question as to *ruficornis* belonging here. He had apparently not seen *ruficornis*. It would seem logical to consider *basizona* as the type of the genus. The other species included by Spinola were *atricornis*, *grohmanni*, and *tarsata*. Patton, 1879, p. 472, gave *Macrocera antennata* Lepeletier = *Eucera antennata* Fabricius = *Apis malvæ* Rossi as the type of *Tetralonia* but, as Spinola did not originally include this, Patton was not in order—or would not now be. See also Cockerell, 1906, p. 105, and 1912*d*, p. 262.

Dalla Torre and Friese, 1895, p. 56, make *Tetralonia* a subgenus of *Eucera*. See also Dalla Torre, 1896, p. 223. Much of the recent literature has considered *Tetralonia* as a distinct genus with *Synhalonia* Patton, 1879 (type: *fulvitarsis*), and *Eusynhalonia* Ashmead, 1899 (type: *edwardsii*), as synonyms. There is considerable confusion with *Xenoglossa* and this is probably the case in Friese's 1916 paper.

Robertson, 1905, p. 366, gives keys to Illinois species under the name *Synalonia* (emended *Synhalonia*). Cockerell, 1912*d*, gives an annotated list and, 1914*a*, p. 284, a key.

acerba Cresson, 1879, p. 210. (*Melissodes*) ♀. NEVADA; (Morrison).

Synhalonia acerba Patton, 1879, p. 474. Suggests that it may be the ♀ of *edwardsii* Cresson.

Synhalonia acerba Fowler, 1899, p. 138. Berkeley and San Mateo County, CALIFORNIA; IV, V (Fowler, 1902, p. 321); at *Brassica campestris* and *Ranunculus californicus*.

Anthophora urbana (misprint for *Synhalonia acerba*) Cockerell, 1905, p. 31. Los Angeles, CALIFORNIA; (Davidson).

actuosa Cresson, 1878*a*, p. 208. (*Melissodes*) ♀. CALIFORNIA; (H. Edwards).

Melissodes actuosa Cockerell, 1905, p. 30. ♂. Lancaster, CALIFORNIA; (Davidson).

Synhalonia actuosa Viereck *et al.*, 1905, p. 318. ♂. Corvallis, OREGON; V, VII.

Bray, 1917, p. 94. Claremont, CALIFORNIA; (Baker).

albicans Provancher, 1896, p. 27. (*Synhalonia*) ♂. Los Angeles, CALIFORNIA; (Coquillett).

Synhalonia albicans Fowler, 1902, p. 321. San Gabriel, CALIFORNIA; VI. Cockerell, 1906, p. 101.

albopilosa Fowler, 1899, p. 138. (*Synhalonia*) ♂. Berkeley, CALIFORNIA; IV; at *Ranunculus californicus*.

Cockerell, 1906, p. 101.

analis. See *Thygater*.

angustior. See *edwardsii*.

annæ Cockerell, 1906, p. 114. ♀. Gibson, NEW MEXICO; IX; (Anna Gohrman).

apiculata. See *Xenoglossa*.

aragalli. See *frater aragalli*.

argyrophila Cockerell, 1909d, p. 147. ♂. Lee County, TEXAS; III; (Birkman).

astragalina Cockerell, 1905a, p. 271. (*Synhalonia*) ♂. Boulder, COLORADO; VI; at *Astragalus*; (W. P. Cockerell).

Cockerell, 1906, p. 101.

atrifrons. See *Melissodes carolinensis*.

atriventris Smith, 1854, p. 310. (*Melissodes*) ♂. "North America?"

Synhalonia atriventris Cresson, 1887, p. 305.

Synhalonia atriventris Robertson, 1891a, pp. 581, 591. At *Mertensia virginica* and *Pentstemon lævigatus digitalis*.

Synhalonia atriventris Robertson, 1897, p. 353. Carlinville and Algonquin, ILLINOIS. These localities are probably correct although the synonymy is wrong; see Cockerell, 1912d, pp. 263, 268, 271.

Cockerell, 1906, p. 101. Eastern States.

Synhalonia atriventris Britton and Viereck, 1906, pp. 210 and 217. CONNECTICUT; at *Ribes oxyacanthoides* and *Pyrus malus*.

Smith, 1910, p. 693. New Brunswick, Jamesburg, and Clementon, NEW JERSEY; V.

Synhalonia atriventris Robertson, 1914, p. 73. Carlinville, ILLINOIS; at Papilionacæ.

Viereck, 1916, p. 733. New Haven, Westville, and Branford, CONNECTICUT; V.

See *illinoensis* and *robertsoni* and *Melissodes dubitata*.

atriventris fuscipes. See *robertsoni*.

barticeps Friese, 1916, pp. 295, 311. ♂. San José, COSTA RICA; (Schmidt).

belfragii Cresson, 1872, p. 278. (*Melissodes*) ♀. Bosque County, TEXAS*; (Belfrage).

Melissodes honesta Cresson, 1872, p. 279. ♂. Bosque County, TEXAS*.

Melissodes honesta Cresson, 1876, p. 209. Green River, WYOMING; (Putnam).

Synhalonia honesta Patton, 1879, p. 474.

Synhalonia honesta Robertson, 1891a pp. 578, 579, 581, 589, 591. At *Polemonium reptans*, *Hydrophyllum appendiculatum*, *Mertensia virginica*, *Collinsia verna*, and *Pentstemon pubescens* and *lævigatus digitalis*.

Synhalonia belfragei Robertson, 1895, p. 126. ILLINOIS.

Synhalonia belfragei Robertson, 1896, p. 160. Carlinville, ILLINOIS; at *Esculus glabra*.

Synhalonia honesta Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.
Cockerell, 1906b, p. 279. On p. 101 he unites *belfragii* and *honesta* on the authority of Robertson.
See *fowleri* and *virgata*.

bifasciata pallescens Friese, 1916, pp. 295, 329. ♀. San José, COSTA RICA; (Schmidt).

birkmanniella Cockerell, 1906, pp. 93, 101. ♂. Fedor, Lee County, TEXAS; IV; (Birkman).

brevicornis. See *Xenoglossa*.

californica Cresson, 1878a, p. 196. (*Melissodes*) ♂. CALIFORNIA; (H. Edwards).

Synhalonia californica Cockerell, 1904, p. 235.
Cockerell, 1906, p. 101.
See *fowleri*.

cajennensis. See *Melissodes*.

chrysobotryæ Cockerell, 1908, p. 332. ♀, ♂. Boulder, COLORADO; V; at *Ribes* or *Chrysobotrya*; (Hite).

chrysophila Cockerell, 1914a, p. 284. ♀. Las Vegas, NEW MEXICO; V; at *Ribes aureum*.

cordleyi Viereck, 1905, p. 316. (*Synhalonia*) ♀, ♂. Corvallis, OREGON; V-VII.

Cockerell, 1906, p. 101.

cordleyi orophila Cockerell, 1914a, p. 284. ♀. Boulder, COLORADO; VI.

costaricensis Friese, 1916, pp. 295, 329. ♂, ♀. San José, and San Mateo, COSTA RICA; (Schmidt).

crenulaticornis Cockerell, 1898, p. 454. (*Melissodes*) ♂. Prude's Summit*, Rio Ruidoso, NEW MEXICO; VII, VIII; at *Geranium atropurpureum*. *Melissodes crenulaticornis maculata* Cockerell, 1898, p. 455. ♂. Big Rock*, Ruidoso, NEW MEXICO; VII; at *Vicia*; (Townsend).

Melissodes crenulaticornis Cockerell, 1899, pp. 156, 157. Mescalero Indian Agency on Tularosa Creek and the Forks of Ruidoso Creek, NEW MEXICO; VII; (Barber).

Synhalonia crenulaticornis Cockerell and Porter, 1899, p. 410.

Cockerell, 1906, pp. 97, 101, and Viereck, 1906, p. 242, Manitou Park, COLORADO; (Snow).

crenulaticornis lippiae. See *Xenoglossodes lippae*.

cressoniana Cockerell, 1905f, p. 177. (*Synhalonia*) ♀. TEXAS; (Cresson Coll.).

Cockerell, 1906, p. 101. TEXAS.

Cockerell, 1909, p. 26. Malcolm, NEBRASKA; IX; at *Salvia*; (Birkman).

dilecta Cresson, 1878a, p. 199. (*Melissodes*) COLORADO*; (Ridings). Bosque County, TEXAS; (Belfrage).

Synhalonia speciosa Cockerell, 1905d, p. 148 (not of Cresson). Fort Collin and Boulder, COLORADO; V; at mountain ash.

Synhalonia speciosa Robertson, 1905, pp. 366, 367 (not of Cresson). ♀, ♂. Carlinville, ILLINOIS.

Cockerell, 1906, pp. 79, 90, 94, 95, 101, 310. Boulder, COLORADO; VI; at *Aragallus*; (W. P. Cockerell). Baldwin, KANSAS; (Bridwell). Las Vegas and Barela Mesa, NEW MEXICO; (Anna Gohrman). Gives the above synonymy.

Cockerell, 1914a, p. 283. Bloomington, INDIANA; V; (Ellis).

See *frater*.

donata Cresson, 1878a, p. 208. (*Melissodes*) ♀. MEXICO; (Sumichrast).

Cockerell, 1906, p. 101.

douglasiana Cockerell, 1906b, p. 278. ♀. Steamboat Rock, Grand Coulee, Douglas County, WASHINGTON; VI; (Melander).

dubitata. See *atriventris*.

edwardsii Cresson, 1878a, p. 195. (*Melissodes*) ♂. CALIFORNIA; (H. Edwards).

Synhalonia edwardsii Patton, 1879, p. 474.

Synhalonia edwardsii race *angustior* Cockerell, 1897a, p. 347. ♂, ♀. Pasco, WASHINGTON; V; (Kincaid).

Synhalonia edwardsii Fowler, 1902, p. 321. Berkeley, CALIFORNIA; III-V; at *Brassica campestris*, *Ranunculus californicus* and *Malvastrum capense*.

Synhalonia edwardsii Viereck et al., 1905, p. 315. Corvallis, OREGON; V-VII. Vernon, BRITISH COLUMBIA; V.

Synhalonia angustior Cockerell, 1905, p. 31. Los Angeles, CALIFORNIA; (Davidson).

Cockerell, 1906, p. 101. NEVADA.

Cockerell, 1914d, p. 365. Claremont, CALIFORNIA; (Essig).

edwardsii latior. See *lata*.

edwardsii vagabunda Cockerell, 1906, pp. 95, 101. ♂. Boulder, COLORADO; VI; (W. P. Cockerell).

Cockerell, 1906a, p. 74. At *Phacelia heterophylla*, not *Onosmodium* as originally reported.

fedoris Cockerell, 1906, pp. 93, 101. ♂. Fedor, Lee County, TEXAS; V; (Birkman). Suggests that it may be a variety of *rosæ* (Robertson).

fervens Smith, 1879, p. 112. ♀, ♂. Mendoza and Santiago, BRAZIL.

Friese, 1916, p. 295. San José, COSTA RICA; (Schmidt).

flagellicornis Smith, 1879, p. 111. ♂. Oaxaca, MEXICO.

fowleri Cockerell, 1905, pp. 14, 28. (*Synhalonia*) ♀. Los Angeles and Lancaster, CALIFORNIA; (Davidson). Suggests that it may be a subspecies of *belfragei* and states that it is the *Synhalonia californica* of Fowler, 1899, p. 137. ♀. Berkeley, CALIFORNIA; V. See Cockerell, 1904, p. 235.

Cockerell, 1906, p. 101. OREGON.

Bray, 1917, p. 94. Claremont, CALIFORNIA; (Baker).

frater Cresson, 1878a, p. 197. (*Melissodes*) ♂. COLORADO; (Morrison).

Synhalonia frater Patton, 1879, p. 474.

Synhalonia frater Robertson, 1895, p. 126. ILLINOIS. Makes *Melissodes speciosa* and *dilecta* (Cresson, 1878a, pp. 198 and 199) synonyms, but see 1905, p. 367.

Synhalonia frater Robertson, 1896, pp. 156, 159, 160, 165. Carlinville, ILLINOIS; at *Podophyllum peltatum*, *Æsculus* and *Gymnocladus canadensis*.

Synhalonia frater Cockerell, 1897a, pp. 347, 348. ♀. ILLINOIS.

Synhalonia frater Robertson, 1898a, pp. 234-237. At *Cornus paniculata*, *Viburnum pubescens* and *prunifolium*.

Synhalonia frater Cockerell, 1899c, p. 3. Baldwin, Douglas County, KANSAS; (Bridwell).

See *speciosa* and *trutta*.

frater aragalli Cockerell, 1904a, p. 25. (*Synhalonia*) ♀. Prospect Lake, Colorado Springs, COLORADO; V; at *Aragallus lamberti*.

Cockerell, 1908a, p. 234. Suggests that it may be the ♀ of *fulvitaris*.

fulvitaris Cresson, 1878a, p. 196. (*Melissodes*) ♂. COLORADO; (Morrison).

Synhalonia fulvitaris Patton, 1879, p. 474. ♀. Como WYOMING; (Williston). Type of *Synhalonia*.

Synhalonia fulvitaris Cockerell, 1905i, p. 204. Fort Collins, COLORADO; V. Cockerell, 1906, p. 101.

Cockerell, 1908a, p. 234. Boulder, COLORADO; V; at vetch; (Mrs. C. Bennett).

See *frater aragalli*.

fulviventris. See *Xenoglossa*.

fulvohirta Cresson, 1878, p. 213. (*Melissodes*) ♂. GEORGIA; (Morrison).

Cockerell, 1906, p. 101.

fuscipes. See *robertsoni*.

fuscotincta Cockerell, 1905f, p. 178. (*Synhalonia*) ♀. Oak Creek Canyon, ARIZONA; 6000 ft.; VIII; (Snow).

gabbii. See *Xenoglossa*.

gillettei. See *speciosa*.

hirsutior Cockerell, 1905, p. 29. (*Synhalonia*) ♂. Banning, CALIFORNIA; (Davidson).

Cockerell, 1906, p. 101.

hirsutissima Cockerell, 1916, p. 428. ♀. BRITISH COLUMBIA; (Beazeley). "It also has a type-written label, 'Toba,' XXX. The locality may be erroneous."

honesta. See *belfragii*.

idiotes Cockerell, 1905, p. 105. (*Synhalonia*) ♀. CALIFORNIA; (Davidson). "Probably a race of *T. stretchii*" (Cockerell, 1912d, p. 264). It is the *Melissodes* sp. of Bull. Soc. Cal. Ac. Sci., IV, p. 14.

illinoensis Robertson, 1902, p. 49. (*Synhalonia*.) ♂. Carlinville (?), ILLINOIS. "May be the male of *atriventris fuscipes*." See *robertsoni*.

intrudens Cresson, 1878, pp. 209 (*nevadensis*), 225; not 1872, p. 102. (*Melissodes*) ♂. NEVADA; (Morrison).

Synhalonia intrudens Patton, 1879, p. 474.

Synhalonia nevadensis Cockerell, 1903b, p. 77. CALIFORNIA.

Cockerell, 1906, p. 101. CALIFORNIA; at *Brassica*.

joseana Friese, 1916, pp. 295, 330. ♂, ♀. San José, COSTA RICA; (Schmidt).

lanierii. See *Florilegus*.

lata Provancher, 1888, p. 302. (*Melissodes*) ♀. Vancouver, BRITISH COLUMBIA; (Taylor).

Synhalonia edwardsii race *laticor* Cockerell, 1897a, p. 347. Olympia (IV-VII, at *Lupinus*) and Seattle (IV, V), WASHINGTON.

Synhalonia lata Viereck, et al., 1905, p. 320. Suggests that it may be the ♀ of or a var. of *edwardsii*.

Cockerell, 1906, p. 101. OREGON.

laticor. See *lata*.

lepida Cresson, 1878, p. 198. (*Melissodes*) ♂. TEXAS*; (Belfrage). COLORADO; (Morrison).

Cockerell, 1906, p. 101.

lippia. See *Xenoglossodes*.

lycii Cockerell, 1897a, p. 348. (*Synhalonia*) ♀. Mesilla Valley, NEW MEXICO; IV; at *Lycium torreyi*, plum, and lilac. See Cockerell, 1897c, p. 28, and 1897e, p. 105.

Cockerell, 1906, pp. 101, 310. Engle, NEW MEXICO. At *Astragalus*.

Cockerell, 1911a, p. 238. Albuquerque, NEW MEXICO; VI; at *Astragalus*; (J. R. Watson).

maculata. See *crenulaticornis*.

medicata Cockerell, 1911, p. 34. ♀. Medicine Hat, ALBERTA; V; (Willing).

nevadensis. Probably *Melissodes*. See *intrudens*.

nigricornis Provancher, 1888, p. 302. (*Melissodes*) ♂. Vancouver, BRITISH COLUMBIA; (Taylor).

Cockerell, 1906, p. 101.

nigripes. See *Melissodes*.

nigroænea. See *Melissodes*.

orophila. See *cordleyi orophila*.

pallescens. See *bifasciata pallescens*.

phaceliæ Cockerell, 1911a, p. 238. ♀. Albuquerque, NEW MEXICO; IV; at *Phacelia corrugata*; (J. R. Watson).

planiventris Friese, 1916, pp. 295, 330. ♀. San José, COSTA RICA; at *Cucurbita*; (Schmidt).

poetica Cockerell, 1914a, p. 424. ♂. Whittier, CALIFORNIA; IV; at *Convolvulus*; (Timberlake).

pomonæ Cockerell, 1915c, p. 230. ♂. Laguna, CALIFORNIA; (La Follette).

Bray, 1917, p. 94. Claremont, CALIFORNIA; (Baker).

pyropyga Friese, 1916, pp. 295, 331. ♂. San José, COSTA RICA; (Schmidt).

robertsoni Cockerell, 1914a, p. 283. ♀. Washington*, DISTRICT OF COLUMBIA; V. Garrison, NEW YORK; (Eleth Cattell).

Synhalonia atriventris form *fuscipes* Robertson, 1900, p. 54. Carlinville, ILLINOIS. The name, *fuscipes*, is preoccupied; see Cockerell, 1912d, p. 264. If this be the ♀ of *illinoensis* Robertson, that name has priority.

Cockerell, 1916d, p. 62. Claremont, CALIFORNIA; (Baker). "Can there be any error in the locality label?"

rossæ Robertson, 1900, p. 54. (*Synhalonia*) ♀. Carlinville, ILLINOIS.

Cockerell, 1906, p. 101.

snoviana. See *speciosa*.

speciosa Cresson, 1878a, p. 198. (*Melissodes*) ♀. COLORADO; (Ridings, Morrison).

(?) *Melissodes speciosa* Cresson, 1876, p. 209. Denver, COLORADO; (Putnam).

Synhalonia speciosa Patton, 1879, p. 474.

Synhalonia speciosa Robertson, 1891a, pp. 578-581, 589, 591. At *Phlox divaricata*, *Hydrophyllum appendiculatum*, *Mertensia virginica*, *Collinsia verna*, and *Pentstemon pubescens* and *laevigatus digitalis*.

Synhalonia speciosa Robertson, 1894, pp. 436-445, 476. Macoupin County, ILLINOIS; at *Prunus serotina*, *Fragaria virginiana illinoensis*, *Pyrus coronaria*, *Crataegus cruegalli*, *Rosa humilis*, and *Krigia amplexicaulis* [*Adopogon virginicum*].

Synhalonia speciosa Robertson, 1895a, pp. 143, 145. ♂, ♀. Carlinville, ILLINOIS; at *Phlox pilosa*.

(?) *Synhalonia speciosa* Fowler, 1902, p. 321. Berkeley, CALIFORNIA; IV, V.
Synhalonia frater Cockerell, 1903b, p. 77. CALIFORNIA (see Cockerell, 1909c, p. 334).

Robertson, 1905, p. 367, says that *speciosa* is not a synonym of *frater*, as he gave it in 1895, p. 128. Carlinville, ILLINOIS.

Synhalonia gillettei Cockerell, 1905i, p. 203. Fort Collins, COLORADO; VI.

Synhalonia gillettei noviana Cockerell, 1905f, p. 179. ♂; Clarke County, KANSAS; 1962 ft.; IV; (Snow).

Synhalonia speciosa Cockerell, 1905d, p. 143. Fort Collins and Boulder, COLORADO; V.

T. gillettei Cockerell, 1906, p. 115. Fedor, TEXAS; V; (Birkman).

Cockerell, 1909c, p. 334. Lee County, TEXAS; VI; at *Scutellaria*; (Birkman).

See *dilecta* and *trutta*.

stretchii Cresson, 1878a, p. 207. (*Melissodes*) ♀. CALIFORNIA; (Stretch).

Cockerell, 1906, p. 101.

See *idiotes*.

tenuifasciata Friese, 1916, pp. 295, 332. ♂, ♀. San José and San Mateo, COSTA RICA; at *Cucurbita*; (Schmidt, Burgdorf).

territella Cockerell, 1905d, p. 146. (*Synhalonia*) ♂. Palisade, COLORADO; V; at *Prunus*; (Gillette).

Cockerell, 1906, p. 101.

trutta Cockerell, 1905d, p. 147. (*Synhalonia*) ♂, ♀. Trout Spring, Gallinas Canyon, NEW MEXICO; V; at *Iris missouriensis*. "*Synhalonia frater* (not of Cresson), Cockerell, Amer. Naturalist, Vol. 36, p. 815 (not description)."

Cockerell, 1906, p. 101. At *Iris*.

vagabunda. See *edwardsii vagabunda*.

virgata Cockerell, 1905, p. 100. (*Synhalonia belfragei* subsp. *virgata*). ♀. Los Angeles, CALIFORNIA; (Davidson).

yakimensis Cockerell, 1906b, p. 278. ♂. Yakima, WASHINGTON; IV; (Melander).

Tetraloniella

See *Xenoglossodes*.

THYGATER Holmberg, 1884, p. 133

(Type: *Tetralonia terminata* Smith)

Macroglossapis Cockerell, 1899b, p. 14 (N. n. for *Macroglossa* Radoszkowsky, 1884, p. 17, not Oechsenheimer), is a synonym. See Cockerell, 1912d, p. 273.

albilabris Cresson, 1878a, p. 209. (*Melissodes*) ♂. MEXICO; (Sumichrast).

Macroglossapis albilabris Cockerell, 1906, p. 74.

Cockerell, 1912d, p. 273.

analís Lepeletier, 1841, p. 104. (*Macrocera*) ♂. BRAZIL.

Tetralonia analís Smith, 1854, p. 304.

Macroglossa oribazi Radoszkowsky, 1884, p. 18. ♀. Orizaba, MEXICO.

Tetralonia analís Friese, 1916, p. 295. San José, COSTA RICA.

Macroglossapis analís Cockerell, 1906, pp. 74, 104.

Cockerell, 1912d, p. 273.

cockerelli Crawford, 1906, p. 160. (*Macroglossapis*) ♀. San José, COSTA RICA; 3550 ft.; V, VI.

Cockerell, 1912b, p. 29. Quirigua, GUATEMALA; (W. P. Cockerell).

modesta Smith, 1879, p. 115. (*Melissodes*) ♂. Oaxaca, MEXICO.

Macroglossapis modesta Cockerell, 1906, p. 74.

Cockerell, 1912d, p. 273.

montezuma Cresson, 1878a, p. 194. (*Melissodes*) ♀*, ♂. MEXICO; (Sumichrast).

Macroglossapis montezuma Cockerell, 1906, pp. 74, 83.

Cockerell, 1912d, p. 273.

nigravillosa Crawford, 1906, p. 160. (*Macroglossapis*). ♂. San José, COSTA RICA; 3550 ft.; VI; at *Impatiens* and *Dahlia*.

Cockerell, 1912b, p. 29. Quirigua, GUATEMALA; II; at *Ipomæa sidæifolia*; (W. P. Cockerell).

oribazi. See *analís*.

rubricata Smith, 1879, p. 113. (*Melissodes*) ♀. Oaxaca, MEXICO.

Macroglossapis rubricata Cockerell, 1906, p. 74.

Cockerell, 1912d, p. 273.

Macroglossapis rubricata Crawford, 1906, p. 159. San José, COSTA RICA; 3550 ft.; VI; at *Dahlia*.

XENOGLOSSA Smith, 1854, p. 315.

(Type: *Xenoglossa fulva* Smith)

Dalla Torre, 1896, p. 223 includes it as a subgenus of *Ewera*. Tables: Cockerell, 1896, p. 192, and 1906, pp. 74-90.

Peponapis Robertson, 1902, p. 324 (*Xenoglossa pruinosa* Say, the type), is considered by Cockerell, 1912d, p. 265, to be a subgenus.

angelica Cockerell, 1902, p. 103. ♂, ♀. Los Angeles, County Farm, and San Diego, CALIFORNIA; VII, VIII; at *Cucurbita fætidissima* and *Ipomæa*.

Peponapis angelica Cockerell, 1903b, p. 77. This is the "*pruinosa* Fowler, not Say."

Cockerell, 1914d, p. 365. Fresno and Orange County, CALIFORNIA; VII. *angustior*. See *patricia angustior*.

apiculata Cresson, 1878a, p. 220. (*Tetralonia*) ♀. COSTA RICA; (Gabb).

assimilis Smith, 1879, p. 114. (*Melissodes*) ♀, ♂. Oaxaca, MEXICO.

Melissodes assimilis Cockerell, 1905e, p. 329. Notes on type.

Xenoglossa (Peponapis) assimilis Cockerell, 1912b, p. 24, and 1912d, p. 265. Quirigua, GUATEMALA; at *Ipomæa*; (W. P. Cockerell).

brevicornis Cresson, 1872, p. 281. (*Melissodes*) ♀. Bosque County, TEXAS; (Belfrage).

Eucera cressonii Dalla Torre, 1896, p. 229. A new name, not for *Tetralonia brevicornis* Smith.

Melissodes brevicornis Crawford, 1903, p. 334. Lincoln, NEBRASKA; VIII; at *Teucrium canadense*.

Xenoglossa brevicornis Cockerell, 1906, pp. 73, 102. NEBRASKA; at *Teucrium*. Fedor, TEXAS; VI; (Birkman).

Cockerell, 1915a, p. 364. Sleeping habits.

See *strenua*.

crawfordi Cockerell, 1910, p. 367. ♂. Guadalajara, MEXICO; (Crawford).

Cockerell, 1917c, p. 481. Guanajuato, MEXICO; (Dugès).

cressonii. See *brevicornis*.

cucurbitarum. See *strenua*.

davidsoni Cockerell, 1905, pp. 14, 28. ♀. Los Angeles, CALIFORNIA; (Davidson).

dugesi Cockerell, 1919, p. 194. ♀. Guanajuato, MEXICO; (Dugès).

exquisita. See *fulviventris*.

fulva Smith, 1854, p. 315. ♀, ♂. Puebla, MEXICO.

Anthophora holopyrrha Dours, 1869, p. 89.

Cockerell, 1896, p. 193. ARIZONA. The record for Lower California is to be deleted, it being due to an error in considering *Centris mustelina* a synonym.

fulviventris Smith, 1854, p. 308. (*Tetralonia*) ♀. MEXICO.

Melissodes exquisita Cresson, 1878a, p. 213. ♀. MEXICO; (Sumichrast).

Cockerell, 1906, p. 102.

Tetralonia fulviventris Cockerell, 1905j, p. 165. Near Sylacoyoapam, Oaxaca, MEXICO. Host of *Triepeolus digueti*.

Tetralonia fulviventris Meade-Waldo, 1914, p. 402. Makes *exquisita* a synonym.

gabbi Cresson, 1878a, p. 220. (*Tetralonia*) ♀*, ♂. COSTA RICA; (Gabb).

Macrocera gabbi Schrottky, 1903, p. 519. BRAZIL.

Cockerell, 1906, pp. 81, 102.

holopyrrha. See *fulva*.

howardi Cockerell, 1918a, p. 420. (Subgenus *Peponapis*) ♂*, ♀.
Federal District* and Oaxaca, MEXICO; IX; (Inda and Howard).

ipomææ. See *Cemolobus*.

kansensis. See *strenua kansensis*.

limitaris. See *pruinosa limitaris*.

mustelina Fox, 1893, pp. 24 and 118. ♀, ♂. San José del Cabo,
Lower California, MEXICO; (Eisen). Described as *Centris* (p. 24)
and made a synonym of *Xenoglossa fulva* (p. 118), but Cockerell,
1905e, p. 328, after examining the type of *fulva*, says it is distinct.

patricia Cockerell, 1896, pp. 191-193, and 1898a, p. 67. ♂, ♀. Mesilla
and Gila River, NEW MEXICO; VI; at *Cucurbita perennis* [= *fetidissima*].

Bequaert, 1918, p. 126. Crepuscular.

patricia angustior Cockerell, 1900b, p. 64. ♂. Buckeye, ARIZONA; X;
at *Cucurbita palmata*.

Cockerell, 1902, p. 103. Los Angeles, CALIFORNIA; VII; at *Cucurbita*
fetidissima.

Cockerell, 1906, pp. 74, 314. Congress Junction, ARIZONA; VII; (Snow).
"Lower Sonoran."

Cockerell, 1914d, p. 365. Fresno, CALIFORNIA; VIII.

pruinosa Say, 1836, p. 405. (*Macrocera*) ♂, ♀. United States.

Melissodes pruinosa Smith, 1854, p. 309. Mount Pleasant, OHIO.

Melissodes pruinosa Cresson, 1876, p. 209. Spring Lake, UTAH; (Putnam).

Patton, 1879, p. 473. At pumpkin.

Gribodo, 1882, p. 274. ARIZONA.

Robertson, 1891a, pp. 574, 581. At *Ipomæa pandurata* and a male found
dead on flower of *Asclepias sullivantii*.

Cockerell, 1896, p. 193. PENNSYLVANIA. NEW YORK. Mesilla, NEW
MEXICO; VI; at *Cucurbita perennis*.

Cockerell, 1899, p. 156. Mescalero Indian Agency, Tularosa Creek, NEW
MEXICO; VII; (C. M. Barber).

Cockerell, 1901a, p. 130. Las Vegas, NEW MEXICO; VII; at *Cucurbita*
fetidissima and *Asclepias speciosa*; (Winters, Holzman, Rishel, Porter).

Peponapis pruinosa Robertson, 1902, p. 324.

Viereck, 1903a, p. 119. College Park, MARYLAND; VII.

X. spriuna Howard, 1904, Pl. VII, Fig. 2.

Peponapis pruinosa Robertson, 1905, p. 365.

Cockerell, 1906, pp. 73, 102, 115, 310. ARIZONA; VIII; (Snow). Lee
County, TEXAS; VI; (Birkman). Pecos, NEW MEXICO.

Smith, 1910, p. 694. Throughout NEW JERSEY; VII-IX.

Cockerell, 1911, p. 390. Woods Hole, MASSACHUSETTS; (Cattell).

Cockerell, 1912*d*, p. 265. Falls Church, VIRGINIA (Banks), west to COLORADO.

Cockerell, 1914*a*. Santa Fé, NEW MEXICO; VIII.

X. (Peponapis) pruinosa Viereck, 1916, p. 733. New Haven and Bristol, CONNECTICUT; VII.

See *angelica*.

pruinosa limitaris Cockerell, 1906*a*, p. 73. ♂. Brownsville, TEXAS; VI; (Snow).

rhodophila Cockerell, 1918*b*, p. 27. ♀. MEXICO; (Baker).

spruina. See *pruinosa*.

strenua Cresson, 1878*a*, p. 213. (*Melissodes*) ♀, ♂*. TEXAS*, GEORGIA, and NEW MEXICO.

Xenoglossa cucurbitarum Cockerell, 1896, p. 192. ♂, ♀. Mesilla, NEW MEXICO; VI; at *Cucurbita perennis*.

Xenoglossa cucurbitarum Robertson, 1899, p. 215. Presumably Carlinville, ILLINOIS; at *Cucurbita pepo*, *Citrullus vulgaris*, *Asclepias cornuti*, and *Ipomoea nil* and *pandurata*. Ames, IOWA; at summer squash; (Alice M. Beach). Metropolis, ILLINOIS; at *Martynia proboscidea*; (Hart). Says that *X. brevicornis* Robertson in Botanical Gazette, XVII, p. 65, is a manuscript name for this species.

Robertson, 1902, p. 324.

Robertson, 1903*b*, p. 77. CALIFORNIA.

Cockerell, 1905*c*, p. 266. Fedor, TEXAS.

Cockerell, 1906, pp. 102, 310. ILLINOIS and IOWA.

Græniche, 1911, p. 247. Hudson in St. Croix County, WISCONSIN; VIII; at *Cirsium arvense* and Cucurbitaceae.

strenua kansensis Cockerell, 1905*g*, p. 104. ♂. Clark County (1962 ft.), Morton County (3200 ft.), Wallace County (3000 ft.), KANSAS; VI; (Snow).

utahensis Cockerell, 1905*f*, p. 182. ♀. UTAH.

XENOGLOSSODES Ashmead, 1899, p. 63

(Type: *Xenoglossa albata* Cresson)

Practically equals *Tetraloniella* Ashmead, 1899, p. 61, of the Old World; see Cockerell, 1911*b*, p. 185. For tables, etc., see Cockerell and Porter, 1899, p. 407; Cockerell, 1903, p. 449; and Cockerell and Robbins, 1910, p. 194.

albata Cresson, 1872, p. 281. (*Melissodes*) ♀, ♂. TEXAS; (Belfrage).

Synhalonia albata Patton, 1879, p. 474.

Synhalonia albata Birkman, 1899, p. 245. Fedor, Lee County, TEXAS.

Cockerell, and Porter, 1899, p. 407.

albocincta. See *Melissodes*.

eriocarpi Cockerell, 1898, p. 453. (*Exomalopsis*) ♀. Fillmore Canyon, Organ Mountains, NEW MEXICO; 5400 ft.; IX; at *Eriocarpum gracile*, now called *Sideranthus gracilis*; (Townsend).

Cockerell and Porter, 1899, p. 407.

Cockerell, 1905c, p. 335. Fedor, TEXAS; VI.

Cockerell, 1906a, p. 72. Brownsville, TEXAS; VI; (Snow).

excurrens Cockerell, 1903, p. 448. ♀. Roswell, NEW MEXICO; VIII.

Melissodes pecosella verbesinarum Cockerell, 1905f, p. 180. ♀. Las Cruces, NEW MEXICO; IX; at *Verbesina encelioides*, now called *Ximenesia exauriculata*.

Melissodes pecosella verbesinarum Cockerell, 1906c, p. 366. At *Isocoma wrightii*. 1906, p. 310: "Middle Sonoran."

Cockerell, 1910, p. 259.

gutierreziae Cockerell, 1905h, p. 218. ♀. Fillmore Canyon, Organ Mountains, NEW MEXICO; VIII; at *Gutierrezia*; (Townsend).

helianthorum Cockerell, 1914b, p. 415. ♂. Falfurrias, TEXAS; V; at *Helianthus*; (Morgan).

imitatrix Cockerell and Porter, 1899, p. 407. ♀, ♂. Las Vegas, NEW MEXICO; VIII; at *Sphaeralcea lobata*; (Garlick, Porter).

Cockerell, 1904a, p. 24. Glorieta, NEW MEXICO; VIII; (W. P. Cockerell).

lippiæ Cockerell, 1904a, p. 25. (*Synhalonia crenulaticornis lippiae*) ♂. La Cueva* and Dripping Spring, Organ Mountains, NEW Mexico; about 5300 ft.; VIII, IX; at *Lippia wrightii*; (Townsend).

Synhalonia lippiae Cockerell, 1905h, p. 224. At *Phacelia congesta*.

Tetralonia lippiae Cockerell, 1906, p. 97. ARIZONA; (Snow).

lippiæ semilippiæ Cockerell, 1905f, p. 179. (*Synhalonia*) ♀. Oak Creek Canyon, ARIZONA; 6000 ft.; VIII; (Snow).

neotomæ Cockerell, 1906, pp. 310, 314. ♀, ♂. Raton, NEW MEXICO; VIII.

saponellus. See *Melissodes*.

semilippiæ. See *lippiæ semilippiæ*.

wilmattæ Cockerell, 1917a, p. 191. ♀. Point Isabel, TEXAS; at a yellow composite; (W. P. Cockerell).

BIBLIOGRAPHY¹

ASHMEAD, WM. H.

- 1899. Trans. American Ent. Soc., XXVI.
- 1900. Trans. Ent. Soc. London.
- 1902. Entomological News, XIII.
- 1902a. Proc. Washington Acad. Sci., IV.

AURIVILLIUS, CHR.

- 1890. Bihang K. Svenska Vet.-Akad. Handlingar, XV part IV [No. 1].

BANKS, NATHAN

- 1902. Journ. New York Ent. Soc., X.
- 1912. Entomological News, XXIII.

BEQUAERT, J.

- 1918. Journ. New York Ent. Soc., XXVI.
- 1920. Psyche, XXVII.

BIRKMAN, G.

- 1899. Entomological News, X.

BLANCHARD, E.

- 1840. Cuvier: Règne anim. 3rd Edition. Insect. II.
- 1840a. Hist. nat. Insect., III.

BOWLES, G. J.

- 1880. Ann. Rept. Ent. Soc. Ontario for 1879.

BRADLEY, J. C.

- 1919. Trans. Ent. Soc. London, 1919.

BRAY, HENRY

- 1917. Journ. Ent. and Zool. (Pomona College, California), IX.

BRITTON, W. E., and VIERECK, H. L.

- 1906. Fifth Rept. State Entomologist of Connecticut.

BURMEISTER, H.

- 1876. Ent. Zeitung, Stettin, XXXVII.

BUYSSON, ROBERT DU

- 1901. Ann. Soc. Ent. France, LXX.

CAMERON, P.

- 1903. Trans. American Ent. Soc., XXIX.

COCKERELL, T. D. A.

- 1893. Trans. American Ent. Soc., XX.
- 1894. Entomological News, V.
- 1896. Canadian Entomologist, XXVIII.
- 1896a. Ann. Mag. Nat. Hist., (6) XVIII.
- 1896b. Entomologist, XXIX.
- 1897. Ann. Mag. Nat. Hist., (6) XIX.
- 1897a. Proc. Acad. Nat. Sci., Philadelphia, XLIX.
- 1897b. Trans. American Ent. Soc., XXIV.
- 1897c. New Mexico College Agric. Mech. Arts, Agric. Exp. Station Bull. No. 24.

¹The reference letters in this list, e. g. 1897a and 1897b, have no chronological significance; b may have been published before a.

- 1897d. Entomologist, XXX.
1897e. Botanical Gazette.
1898. Ann. Mag. Nat. Hist., (7) II.
1898a. Bull. University of New Mexico, I. [A reprint of 1898d.]
1898b. Proc. Acad. Nat. Sci., Philadelphia, L.
1898c. Trans. American Ent. Soc., XXV.
1898d. Bull. Sci. Lab. Dennison University, XI. [Reprinted in 1898a.]
1898e. Canadian Entomologist, XXX.
1898f. Zoologist.
1899. Entomologist, XXXII.
1899a. Ann. Mag. Nat. Hist., (7) IV.
1899b. 'Catálogo de las Abejas de Mexico.' Biblioteca Agricola de la
Secretaria de Fomento, Mexico.
1899c. Entomological News, X.
1899d. Canadian Entomologist, XXXI.
1900. Canadian Entomologist, XXXII.
1900a. Ann. Mag. Nat. Hist., (7) V.
1900b. Entomologist, XXXIII.
1901. Canadian Entomologist, XXXIII.
1901a. Ann. Mag. Nat. Hist., (7) VII.
1901b. Psyche, IX.
1901c. Entomological News, XII.
1902. Entomological News, XIII.
1902a. Entomologist, XXXV.
1902b. Ann. Mag. Nat. Hist., (7) IX.
1902c. Ann. Mag. Nat. Hist., (7) X.
1903. Ann. Mag. Nat. Hist., (7) XII.
1903a. American Naturalist, XXXVII.
1903b. Psyche, X.
1904. Entomologist, XXXVII.
1904a. Ann. Mag. Nat. Hist., (7) XIV.
1904c. Entomological News, XV.
1904d. Canadian Entomologist, XXXVI.
1904e. Bull. Southern California Acad. Sci., III. (No. 9, pp. 145-168, was
mailed January 9, 1905.)
1905. Bull. Southern California Acad. Sci., IV.
1905a. Entomological News, XVI.
1905b. American Naturalist, XXXIX.
1905c. Canadian Entomologist, XXXVII.
1905d. Entomologist, XXXVIII.
1905e. Trans. American Ent. Soc., XXXI.
1905f. Proc. Biol. Soc. Washington, XVIII.
1905g. Psyche, XII.
1905h. Ann. Mag. Nat. Hist., (7) XVI.
1905i. Ann. Mag. Nat. Hist., (7) XV.
1905j. Bull. Mus. Nat. Hist., Paris, XI.
1906. Trans. American Ent. Soc., XXXII.
1906a. Ann. Mag. Nat. Hist., (7) XVIII.

- 1906b. Canadian Entomologist, XXXVIII.
- 1906c. Ann. Mag. Nat. Hist., (7) XVII.
- 1906d. Bull. American Mus. Nat. Hist., XXII.
- 1906e. Bull. Mus. Comparative Zoology, L.
- 1907. Entomological News, XVIII.
- 1907a. Canadian Entomologist, XXXIX.
- 1907b. University of Colorado Studies, IV.
- 1907c. Entomologist, XL.
- 1907d. Ann. Mag. Nat. Hist., (7) XIX.
- 1907e. Ann. Mag. Nat. Hist., (7) XX.
- 1908. Ann. Mag. Nat. Hist., (8) II.
- 1908a. Canadian Entomologist, XL.
- 1908b. Ann. Mag. Nat. Hist., (8) I.
- 1908c. Psyche, XV.
- 1908d. American Naturalist, XLII.
- 1909. Ann. Mag. Nat. Hist., (8) IV.
- 1909a. Proc. U. S. Nat. Mus., XXXVI.
- 1909b. Entomological News, XX.
- 1909c. Canadian Entomologist, XLI.
- 1909d. Entomologist, XLII.
- 1909e. Trans. Kansas Acad. Sci., XXII.
- 1910. Ann. Mag. Nat. Hist., (8) V.
- 1910a. Canadian Entomologist, XLII.
- 1910b. Ann. Mag. Nat. Hist., (8) VI.
- 1910d. Univ. of Colorado Studies, VII.
- 1911. Canadian Entomologist, XLIII.
- 1911a. Trans. American Ent. Soc., XXXVII.
- 1911b. Ann. Mag. Nat. Hist., (8) VIII.
- 1912. Psyche, XIX.
- 1912a. Ann. Mag. Nat. Hist., (8) IX.
- 1912b. Ann. Mag. Nat. Hist., (8) X.
- 1912c. Entomological News, XXIII.
- 1912d. Proc. U. S. Nat. Mus., XLIII.
- 1912e. Canadian Entomologist, XLIV.
- 1912f. University of Colorado Studies, IX.
- 1913. Psyche, XX.
- 1913a. Ann. Mag. Nat. Hist., (8) XI.
- 1913b. Ann. Mag. Nat. Hist., (8) XII.
- 1914. Entomologist, XLVII.
- 1914a. Ann. Mag. Nat. Hist., (8) XIII.
- 1914b. Canadian Entomologist, XLVI.
- 1914c. Journ. New York Ent. Soc., XXII.
- 1914d. Ann. Mag. Nat. Hist., (8) XIV.
- 1914e. Proc. Ent. Soc. Washington, XVI.
- 1915. Ann. Mag. Nat. Hist., (8) XV.
- 1915a. Entomological News, XXVI.
- 1915b. Ann. Mag. Nat. Hist., (8) XVI.
- 1915c. Journ. Ent. and Zool. (Claremont, California), VII.

- 1915d. *Botanical Gazette*, LIX.
1916. *Ann. Mag. Nat. Hist.*, (8) XVII.
1916a. *Occ. Papers Mus. Zool. Univ. of Michigan*, No. 24.
1916b. *Canadian Entomologist*, XLVIII.
1916c. *Occ. Papers Mus. Zool. Univ. of Michigan*, No. 23.
1916d. *Journ. Ent. and Zool. (Claremont, California)*, VIII.
1917. *Entomological News*, XXVIII.
1917a. *Journ. New York Ent. Soc.*, XXV.
1917b. *Ann. Mag. Nat. Hist.*, (8) XX.
1917c. *Ann. Mag. Nat. Hist.*, (8) XIX.
1917d. *Psyche*, XXIV.
1917e. *Canadian Entomologist*, XLIX.
1918. *Ann. Mag. Nat. Hist.*, (9) I.
1918a. *Ann. Mag. Nat. Hist.*, (9) II.
1918b. *Trans. American Ent. Soc.*, XLIV.
1919. *Proc. U. S. Nat. Museum*, LV.
1919a. *Ann. Mag. Nat. Hist.*, (9) III.
1919b. *Entomological News*, XXX.
1919c. *Canadian Entomologist*, LI.
1919d. *Ann. Mag. Nat. Hist.*, (9) IV.
1920. *Ann. Mag. Nat. Hist.*, (9) V.
1920. *Bull. Amer. Mus. Nat. Hist.*, XLII.
COCKERELL, T. D. A. and W. P.
1901. *Ann. Mag. Nat. Hist.*, (7) VII.
COCKERELL, T. D. A. and McNARY, JOHN
1902. *Canadian Entomologist*, XXXIV.
COCKERELL, T. D. A. and PORTER, W.
1899. *Ann. Mag. Nat. Hist.*, (7) IV.
COCKERELL, T. D. A. and ROBBINS, W. W.
1910. *University of Colorado Studies*, VII.
COCKERELL, W. P.
1912. *Canadian Entomologist*, XLIV.
COCKLE, J. WM.
1913. *Canadian Entomologist*, XLV.
COVILLE, F. V.
1890. *Proc. Ent. Soc. Washington*, I.
CRAWFORD, J. C., JR.
1902. *Canadian Entomologist*, XXXIV.
1903. *Canadian Entomologist*, XXXV.
1906. *Trans. American Ent. Soc.*, XXXII.
1907. *Canadian Entomologist*, XXXIX.
1912. *Canadian Entomologist*, XLIV.
1913. *Canadian Entomologist*, XLV.
1914. *Proc. U. S. National Museum*, XLVII.
1915. *Proc. U. S. National Museum*, XLVIII.
CRAWFORD, J. C., and SWENK, M. H.
1903. *Canadian Entomologist*, XXXV.

CRESSON, E. T.

- 1863. Proc. Ent. Soc. Philadelphia, II.
- 1864. Proc. Ent. Soc. Philadelphia, III.
- 1865. Proc. Ent. Soc. Philadelphia, IV.
- 1868. Trans. American Ent. Soc., I.
- 1869. Trans. American Ent. Soc., II.
- 1872. Trans. American Ent. Soc., IV.
- 1874. Trans. American Ent. Soc., V.
- 1875. Rept. Geog. Geol. Explor. and Surveys W. of 100th Meridian, V.
- 1876. Proc. Davenport Acad. Nat. Sci., I.
- 1878. Trans. American Ent. Soc., VII. After p. 200 published in 1879.
- 1878a. Proc. Acad. Nat. Sci., Philadelphia, XXX.
- 1879. Trans. American Ent. Soc., VII.
- 1887. Synopsis of the Hymenoptera of America, North of Mexico. Trans. American Ent. Soc., Supplementary Volume.
- 1916. Memoirs American Ent. Soc., No. 1.

CURTIS, JOHN

- 1835. 'Descriptions, etc., of the Insects Brought Home by Commander James Clark Ross, Appendix to the Narrative of a second Voyage in search of a Northwest Passage. . . . ' by Sir John Ross.

DÄCKE, E.

- 1907. Entomological News, XVIII.

DAHLBOM, A. G.

- 1832. 'Bombi Scandinaviæ . . . '

DALLA-TORRE, C. G.

- 1882. Ber. naturw.-mediz. Ver. Innsbruck, XII.
- 1890. Wiener Ent. Zeitung, IX.
- 1896. 'Catalogus Hymenopterorum,' X. (Engelmann).

DALLA-TORRE, C. G., and FRIESE, H.

- 1895. Ent. Nachrichten, XXI.

DAVIDSON, A.

- 1911. Bull. Southern California Acad. Sci., X.

DE GEER, C.

- 1773. 'Mémoires pour servir à l'histoire des Insectes,' III.

DIVEN, E. L.

- 1916. Entomological News, XXVII.

DOURS, A.

- 1869. Mem. Soc. Linneene Nord France, II. (This is quoted here as of 1869, following Dalla-Torre and others, but it seems to have been published in 1870.)

DUCKE, A.

- 1901. Zeit. Hymen. Dipt., I.
- 1902. Zool. Jahrb., Abt. Systematik, XVII, [1903].
- 1902a. Boletín do Museu Paraense, III (see also 1902b).
- 1902b. Allg. Zeits. Ent., VII.
- 1903. Allg. Zeits. Ent., VIII.
- 1910. Deutsch. Ent. Zeitschr., 1910.
- 1912. Zool. Jahrb., Abt. Systematik, XXXIV.

ERICHSON, W. F.

1848. Schonburgk: 'Reisen in Britisch Guiana,' III.

EVANS, J. D.

1896. Canadian Entomologist, XXVIII.

FABRICIUS, J. CHRIST.

1775. 'Systema Entomologiæ.'
 1787. 'Mantissa Insectorum,' I.
 1793. 'Entomologia Systematica emendata. . .,' II.
 1798. 'Suppl. Entom. System.'
 1804. 'Systema Piezatorum.'

FABRICIUS, O.

1780. 'Fauna Groenlandica. . .'

FAIRCHILD, D., and BARRETT, O. W.

1906. Proc. Ent. Soc. Washington, VIII.

FLETCHER, J. and GIBSON, A.

1907. 38th. Ann. Rept. Ent. Soc. Ontario.
 1908. 39th. Ann. Rept. Ent. Soc. Ontario.

FOWLER, C.

1899. Canadian Entomologist, XXXI.
 1902. Rept. Agric. Exp. Station University of California for 1898-1901.

FOX, WM. J.

1891. Trans. American Ent. Soc., XVIII.
 1892. Proc. Acad. Nat. Sci., Philadelphia, XLIV.
 1893. Proc. California Acad. Sci., (2) IV.
 1895. Proc. California Acad. Sci., (2) V.
 1899. Proc. Acad. Nat. Sci., Philadelphia, LI.

FRANKLIN, H. J.

1907. Entomological News, XVIII.
 1911. Trans. American Ent. Soc., XXXVII.
 1913. Trans. American Ent. Soc., XXXVIII.
 1913a. Trans. American Ent. Soc., XXXIX.
 1915. Entomological News, XXVI.

FRIESE, H.

- 1897a. 'Die Bienen Europa's (Apidæ Europææ) . . .,' III. Berlin.
 1898. Természetrájsi Füzetek, XXI.
 1899. Természetrájsi Füzetek, XXII, [1900].
 1899a. Annal. K. K. Naturhist. Hofmuseums, XIV.
 1899b. Természetrájsi Füzetek, XXII.
 1900. Annal. K. K. Naturhist. Hofmuseums, XV.
 1900a. Természetrájsi Füzetek, XXIII.
 1901. Zeit. Hymen. Dipt., I.
 1902. Zeit. Hymen. Dipt., II.
 1902a. 'Fauna Arctica,' II. Jena (Fischer).
 1903. Zeit. Hymen. Dipt., III.
 1903a. Annal. hist.-nat. Musei Nation. Hungarici, I.
 1904. Annal. hist.-nat. Musei Nation. Hungarici, II.
 1904a. Zeit. Hymen. Dipt., IV.
 1904b. Anal. Mus. Zool. Acad. Imp. Sci. St. Pétersbourg, IX.

1906. *Flora og Fauna, Aarbog for Naturvenner og naturhistoriske Samlere*, VIII.
1908. *Zool. Jahrb., Suppl. XI.* [Distributed Jan. 26, 1909]
- 1908a. *Mém. Acad. Sci. St. Pétersbourg*, (8) XVIII.
1911. *Deutsche Ent. Zeits.*
1912. *Archiv. Naturgeschichte*, LXXVIII, 6.
- 1912a. *Archiv. Naturgeschichte*, LXXVIII, 12.
- 1912b. *Zool. Jahrb., Supplement XV, Bd 1.*
1916. *Ent. Zeit., Stettin*, LXXVII.
- FRIESE, H., and WAGNER, F. V.
1910. *Zool. Jahrb., Abt. Syst.*, XXIX.
- FRISON, T. H.
1919. *Bull. American Mus. Nat. Hist.*, XLI.
- GEMAR, E. F.
1815. *Mag. f. Ent.*, I.
- GIRARD, M.
1874. *Ann. Soc. Ent. France*, (5) IV, Bull.
- GRÆNICHER, S.
1906. *Bull. Wisconsin Nat. Hist. Soc.*, IV.
1907. *Bull. Wisconsin Nat. Hist. Soc.*, V.
1911. *Bull. Public Mus. Milwaukee*, I.
- GREENE, J. W.
- 1858-1862. *Ann. Lyceum Nat. Hist., New York*, VII.
- GRIBODO, G.
1882. *Ann. Mus. civ. Genova*, XVIII.
1891. *Bull. Soc. Ent. Italiana*, XXIII.
1893. *Bull. Soc. Ent. Italiana*, XXV.
- GRONEN, D. (?).
1881. *Zool. Garten*, XXII.
- GROSSBECK, J. A.
1911. *Journ. New York Ent. Soc.*, XIX.
- GUÉRIN-MÉNEVILLE, F. E.
- 1829-1844. '*Iconographie du Règne Animal*,' III, de G. Cuvier. Paris.
- GUIGNARD, J. A.
1886. *Canadian Entomologist*, XVIII.
- HANDLIRSCH, A.
1888. *Annal K. K. naturhist. Hofmuseums Wien*, III.
- 1888a. *Il Naturalista Siciliano*, VIII.
1891. *Annal K. K. naturhist. Hofmuseums Wien*, VI.
- HARRIS, J. ARTHUR and KUCHS, OSCAR M.
1902. *Science Bull. I (Bull. University of Kansas, II, No. 8).*
- HARRIS, T. W.
1835. *Catal. Insects Massachusetts.*
- HARVEY, F. L., and KNIGHT, O. W.
1897. *Psyche*, VIII.
- HOLLAND, W. J.
1917. *Annals Carnegie Museum*, XI.

- HOLMBERG, E. L.
 1884. *Actas Acad. Nac. Ciencias Córdoba*, V.
 1903. *Anales Mus. Nac. Buenos Aires*, (3) II.
- HOWARD, L. O.
 1889. *Insect Life*, I.
 1891. *Insect Life*, III.
 1904. 'Insect Book.'
- HUARD, V. A.
 1897. *Le Naturaliste Canadian*, XXIV.
- HUNGERFORD, H. B., and WILLIAMS, F. X.
 1912. *Entomological News*, XXIII.
- HERING, R. VON
 1903. *Zool. Jahrb., Abt. Syst.*, XIX.
- ILLIGER, K.
 1806. *Mag. f. Insektenkunde*, V.
- JARVIS, T. D.
 1905. 36th Ann. Rept. Ent. Soc. Ontario.
- JOHNSON, S. A.
 1903. *Entomological News*, XIV.
- JURINE, LOUIS
 1807. 'Nouvelle méthode de classer les Hyménoptères et les Diptères.'
- KELLOGG, V. L.
 1908. 'American Insects.' (Henry Holt)
- KIRBY, WM.
 1821. 'Anim. Parry's First Voyage.' Supplement to Appendix.
 1837. 'Fauna Boreali-Americana,' IV. Reprinted by Bethune, *Canadian Entomologist*, VII, IX, and X.
- KLUG, FR.
 1807. *Mag. f. Insektenkunde*, VI.
 1810. *Mag. Ges. naturf. Fr. Berlin*, IV.
- KNAB, F.
 1911. *Proc. Ent. Soc. Washington*, XIII.
- LAMARCK, J. B.
 1817. 'Histoire naturelle des Animaux sans Vertèbres,' IV, Paris.
- LATREILLE, P. A.
 1802. 'Histoire naturelle des Fourmis.'
 1802a. 'Histoire naturelle . . des Crustacés et des Insectes,' III.
 1803. 'Nouveau Dictionnaire d'Histoire Naturelle,' IX.
 1804. *Ann. Mus. hist. nat.*, V.
 1809. 'Genera Crustaceorum et Insectorum,' IV.
 1811. Humboldt and Bonpland, 'Voyage aux Régions Equinoxiales du Nouveau Continent,' Zoology, I.
 1825. 'Familles naturelles du Règne. Animal.'
- LE PELETIER DE SAINT-FARGEAU, A. L. M.
 1825. 'Encyclopédie Méthodique,' X.
 1832. *Ann. Soc. Ent. France*, I.
 1836. 'Histoire naturelle des Insectes.' Hymen., I.
 1841. 'Histoire naturelle des Insectes.' Hymen., II.

- LINNÆUS, C.
1758. 'Systema naturæ, I.' 10th Ed.
- LOVELL, J. H.
1898. Asa Gray Bulletin, VI, No. 4.
1898a. Bull. Torrey Botanical Club, XXV.
- LOVELL, J. H., and COCKERELL, T. D. A.
1906. Psyche, XIII.
1907. Entomological News, XVIII.
- LUCAS, P. H.
1856. 'Histoire Physique, Politique et Naturelle de L'isle de Cuba.' by
M. Ramon de la Sagra. [1857].
- LUTZ, FRANK E.
1916. Bull. American Mus. Nat. Hist., XXXV.
- MACLACHLAN, ROBERT
1878 (1877). Journ. Linnean Soc. London. Zoology, XIV.
- MEADE-WALDO, G.
1913. Ann. Mag. Nat. Hist., (8) XII.
1914. Ann. Mag. Nat. Hist., (8) XIII.
1916. Ann. Mag. Nat. Hist., (8) XVII.
- MEEHAN, T.
1902. Proc. Acad. Nat. Sci., Philadelphia, LIV.
- MEUNIER, F.
1888. Il Naturalista Siciliano, VII.
1890. Journ. sc. Lisboa, (2) II.
- MOCŠÁRY, ALEXANDRO
1896. Természetráji Füzetek, XIX.
1897. Természetráji Füzetek, XX.
1898. Természetráji Füzetek, XXI.
1899. Természetráji Füzetek, XXII.
1908. Annales hist-nat. Mus. Nation. Hungarici, VI.
- MORICE, F. D. and DURRANT, J. H.
1914. Trans. Ent. Soc. London, 1914.
1916. Trans. Ent. Soc. London, 1916.
- MORRILL, A. W.
1903. Canadian Entomologist, XXXV.
- MÜLLER, F.
1875. Zool. Garten, XVI.
- NEWMAN, E.
1834. Entomological Magazine, II.
- NICHOLS, M. L.
1911. Psyche, XX.
- NYLANDER, WM.
1848. Notis. Saellsk. faun. fl. Fennica, Förh. I [Adnot.].
- OLIVIER, A. C.
1789. 'Encyclopédie Méthodique,' Ins., IV.
- PACKARD, A. S., JR.
1864. Proc. Essex Inst., VI.
1869. First Rept. Peabody Acad. Sci.

- PANZER, G. W. F.
1801. *Erlangen Litteratur-Zeitung*. For a discussion of this paper, see Morice and Durrant, 1914 and 1916; also Bradley, 1919.
1805. 'Faunæ Insectorum Germanicæ,' VIII.
- PATTON, W. H.
1879. *Bull. U. S. Geol. Geog. Survey Territories*, V.
- PÉREZ, J.
1905. *Bull. Mus. Hist. Naturelle Paris*, XI.
- PERTY, J. A. M.
1833. 'Delectus Animalium Articulorum. . . Brasil . . .'
- PROVANCHER, L.
1882. *Le Naturaliste Canadien*, XIII.
1883. 'Faun. Entom. Canada Hymen.'
1888 or 1889 (?). 'Additions et Corrections au Vol. II de la Faune entomologique du Canada traitant des Hyménoptères.' Quebec.
1895. *Le Naturaliste Canadien*, XXII.
1896. *Le Naturaliste Canadien*, XXIII.
- PUTNAM, F. W.
1864. *Proc. Essex Instit.*, IV.
- PUTNAM, J. D.
1876. *Proc. Davenport Acad. Nat. Sci.*, I.
- RADOSZKOWSKY, O.
1859. *Bull. Soc. Natural Moscow*, XXXII.
1862. *Bull. Soc. Nat. Moscow*, XXXV.
1884. *Horæ Soc. Ent. Rossicæ*, XVIII.
1884a. *Bull. Soc. Nat. Moscow*, LIX.
- RILEY, C. V.
1870. *American Entomologist and Botanist*, II.
1877. *Trans. Acad. St. Louis*, III.
1880. *American Entomologist*, III (2nd series, I).
- RITSEMA, C.
1880. *Tijds. Ent., Nederlandsche Ent. Vereen.*, XXIII.
- ROBERTSON, CHAS.
1890. *Entomological News*, I.
1891. *Trans. American Ent. Soc.*, XVIII.
1891a. *Trans. St. Louis Acad. Sci.*, V.
1892. *American Naturalist*, XXVI.
1894. *Trans. Acad. St. Louis*, VI.
1895. *Trans. American Ent. Soc.*, XXII.
1895a. *Botanical Gazette*, XX.
1896. *Trans. Acad. Sci. St. Louis*, VII.
1896a. *Botanical Gazette*, XXII.
1897. *Trans. Acad. Sci. St. Louis*, VII.
1897a. *Canadian Entomologist*, XXIX.
1898. *Trans. Acad. Sci. St. Louis*, VIII.
1898a. *Botanical Gazette*, XXV.
1899. *Botanical Gazette*, XXVIII.
1900. *Trans. Acad. Sci. St. Louis*, X.

1901. Canadian Entomologist, XXXIII.
 1901a. Botanical Gazette, XXXII.
 1902. Canadian Entomologist, XXXIV.
 1903. Trans. American Ent. Soc., XXIX.
 1905. Trans. American Ent. Soc., XXXI.
 1914. Entomological News, XXV.
 1918. Canadian Entomologist, L.
 1920. Bull. Brooklyn Ent. Soc., XV.
- ROMAND, B. E. DE
 1841. Mag. de zool., XI.
- SAY, THOMAS
 1834-1837. Boston Journ. Nat. Hist., I.
- SCHMIEDEKNECHT, H. L. O.
 1878. Jenaisch. Zeits. f. Naturw., XII.
 1882. 'Apidæ Europææ.'
- SCHÖNHERR, C. J.
 1809. Svensk. Vet.-Akad. Handl., XXX.
- SCHROTTKY, C.
 1902. Anales Mus. Nac. Buenos Aiers, (2) IV.
 1903. Revista do Museu Paulista, V, (1902).
 1905. Anales Cientificos Paraguayos, No. 4, Series I.
 1907. Anales Cientificos Paraguayos, No. 7, Series I.
 1909. Anales Soc. Cientifica Argentina, LXVII.
 1909a. Proc. Ent. Soc. Washington, XI.
 1914. Deutsche Ent. Zeit.
- SCHULZ, W. A.
 1902. Allg. Zeit. Ent., VII.
 1904. Sitzber. Akad. München, XXXIII.
- SCHWARZ, F. A.
 1896. Proc. Ent. Soc. Washington, IV.
- SICHEL, O.
 1862. Ann. Soc. Ent. France, (4) II.
- SILVESTRI, F.
 1903. Redia, I.
 1911. Portici Boll. Lab. Zool., V.
- SLADEN, F. W. L.
 1915. Canadian Entomologist, XLVII.
 1918. Canadian Entomologist, L.
 1919. Canadian Entomologist, LI.
 1919a. Report of the Canadian Arctic Expedition, 1913-1918, III, part G.
- SMITH, FREDERICK
 1854. 'Catalogue of Hymenopterous Insects in the Collection of the British Museum.' Part II. 'Apidæ.'
 1857. Entom. Annual, 1857.
 1861. Journ. Entomology, I.
 1862. Trans. Ent. Soc. London, (3) I.
 1863. Trans. Ent. Soc. London, (3) I.
 1866. Lord: 'The Naturalist in Vancouver Island and British America.'
 II. London.

1874. *Ann. Mag. Nat. Hist.*, (4) XIII.
1879. 'Descriptions of New Species of Hymenoptera in the Collection of the British Museum.'
- SMITH, J. B.
1910. *Annual Rept. New Jersey State Museum*, [1909]. The former editions of 'The Insects of New Jersey' are not listed here.
- SPINOLA, W. A. M.
1806. 'Insectorum Liguriæ . . .', I.
1838. *Annales Soc. Ent. France*, VII.
1840. *Annales Sc. Nat. Zool.*, (2) XIII.
1861. *Mem. accad. Sc. Torino*, (2) XIII.
- STEVENS, O. A.
1919. *Canadian Entomologist*, LI.
- STRAND, E.
1910. *Zool. Jahrb. Abt. Syst.*, XXIX.
- SWENK, M. H.
1907. *Entomological News*, XVIII.
1909. *Entomological News*, XX.
- TASCHENBERG, E.
1883. *Berliner Ent. Zeitschrift*, XXVII.
- TITUS, E. G.
1902. *Canadian Entomologist*, XXXIV.
1908. *Biol. Survey of Michigan. Ecology of Isle Royale, Lake Superior.* (Published 1909)
- TOWNSEND, C. H. T.
1896. *Canadian Entomologist*, XXVIII.
- TUCKER, E. S.
1909. *Trans. Kansas Acad. Sci.*, XXII.
- UHLER, P. R.
1877. *Bull. U. S. Geol. and Geog. Survey of the Territories*, III.
- VACHAL, J.
1909. *Annales Soc. Ent. France*, LXXXVIII.
- VIERECK, H. L.
1901. *Entomological News*, XII.
1902. *Trans. American Ent. Soc.*, XXIX, [1903].
1903a. *Entomological News*, XIV.
1903b. *Proc. Acad. Nat. Sci., Philadelphia*, LIV, [1902].
1904. *Canadian Entomologist*, XXXVI.
1906. *Trans. American Ent. Soc.*, XXXII.
1916. [Connecticut] *State Geol. and Nat. Hist. Survey, Bull.* 22.
- VIERECK, H. L., assisted by T. D. A. COCKERELL, E. S. G. TITUS, J. C. CRAWFORD, JR., and M. H. SWENK.
1904. *Canadian Entomologist*, XXXVI.
1905. *Canadian Entomologist*, XXXVII.
- WALSH, BENJ. D.
1868. *American Entomologist*, I.
- WASHBURN, F. L.
1919. *17th Rept. State Entomologist of Minnesota.*

- WEISS, H. B.
1917. Entomological News, XXVIII.
- WELLMAN, C.
1911. Entomological News, XXII.
- WESTWOOD, J. O.
1840. Duncan: 'Natural History of Bees.'
- WHEELER, W. M.
1913. Psyche, XX.
- ZABRISKIE, J. L.
1909. Journ. New York Ent. Soc., XVII.
- ZETTERSTEDT, J. W.
1838 (1840 ?). 'Insecta Lapponica,' I.

ADDENDUM

A paper by Adolpho Ducke, entitled 'Enumeração dos Hymenopteros colligidos pela Comissão e Revisão das especies de abelhas do Brazil,' Comissão de Linhas Telegraphicas Estrategicas de Matto Grosso ao Amazonas (Publicação No. 35), Anexo No. 5, Historia Natural, Zoologia, was received in October 1920, although it is dated 1916. It chiefly concerns the Meliponidæ but, as our paper was then in page proof, we could not include his somewhat drastic changes in taxonomy.

Prof. Cockerell has written from London as follows. "I have found in the British Museum the type of *Ancyloscelis ursinus* Haliday, and it is the genus we have as *Leptergatis* (*armatus* Smith). *Ancyloscelis* is the proper name for this genus. *Leptergatis halictoides* Holmberg is also in the Museum and is not congeneric with the above; it is very near *Melitoma*." Unfortunately, this also was received after our paper was in page proof. Furthermore, in justice to Prof. Cockerell, it should be said that none of the proof has had the benefit of his revision.

FRANK E. LUTZ.

Article XVI.—THE JURASSIC AMMONITE FAUNA OF CUBA

BY MARJORIE O'CONNELL, Ph. D.

PLATES XXXIV TO XXXVIII

INTRODUCTION

In 1910 Dr. Carlos de la Torre of the University of Havana announced the discovery of Jurassic ammonites at Viñales in the Province of Pinar del Rio, western Cuba. No species were described and the generic identifications appear to have been incorrect, leading to a mistaken correlation of the formations at Viñales with those of the Upper Jurassic (Kimmeridgian) of Mazapil, Mexico.¹ In the summers of 1918 and 1919 Mr. Barnum Brown made an extensive collection of ammonites from Viñales and numerous other localities in Pinar del Rio, the material thus obtained revealing a large and varied fauna sufficient to determine an accurate zonal succession and make possible a detailed correlation with synchronous formations in Mexico and Europe. Besides this material I have also had for study some sixty-odd specimens sent to me by Dr. Mario Sanchez Roig of Havana, to whom I wish to express my thanks for his courtesy and generosity. Dr. la Torre gave to Mr. Brown some unlabelled specimens from his type locality and these I have identified. Dr. T. W. Stanton, of the United States Geological Survey, kindly loaned me his own collection of ammonites from the Kimmeridgian and Portlandian of Mazapil, while from Professor A. W. Grabau, of the Palæontological Museum of Columbia University, I secured the loan of some very fine specimens of the genus *Idoceras*, also from Mazapil. I have thus been enabled to compare the Cuban and Mexican faunas and to determine their true relations.

In the present paper I shall describe only a small part of the entire fauna, selecting a few species which conclusively establish the fact that the rocks formerly supposed to be of Kimmeridgian age really belong to the Upper Oxfordian. I have studied the material from the point of view of ontogeny, dwelling upon the biological principles illustrated in the development of these ammonites. The stratigraphy, field relations, correlations and palæogeography will be taken up in a more extended report which is now in the course of preparation, and in which will be included the descriptions of many more genera and species, together

¹Da la Torre. 1910. Comprobation de l'existence d'un horizon jurassique dans la région occidentale de Cuba. Compte Rendu, Congrès géologique international, XIe, Stockholm, pp. 1021-1022.

with faunal lists for the successive palæontological zones of the Jurassic. All of the types described below are from the material collected by Mr. Brown and are in the collections of the Department of Geology and Invertebrate Palæontology of The American Museum of Natural History.

While this paper was in the editor's hands, preparatory to publication, there appeared among the agricultural reports of Cuba a paper entitled 'La Fauna Jurásica de Viñales' by Doctor Mario Sanchez Roig,¹ containing brief descriptions of a large number of specimens collected by him and his father. The species which I had identified for them in 1918 and 1919 are there figured and described, while the age of the formations which I determined from the fossils is also included. In addition they included certain species which are incorrectly identified as, for instance, all of those referred to the genus *Idoceras* and figured on Pl. x, figs. 5-7, and Pl. xi, figs. 1-5. I have seen some of the material identified by Dr. Roig as *Idoceras*; it all belongs to the genus *Perisphinctes*, as do also the specimens figured in his paper. On page 669 I have explained how a superficial resemblance of the Cuban species of *Perisphinctes* to the Mexican species of *Idoceras* may lead to incorrect identifications and to consequent errors in correlation. A misleading feature of Dr. Roig's paper is his inclusion, without quotation marks, of entire descriptions of Mexican species translated verbatim from Burckhardt's publications into Spanish, with often not a single word about the Cuban specimen, as for instance, under *Haploceras fialar* on pp. 40, 41. What appears as a description of the Cuban form is actually a translation of Burckhardt's description of *H. fialar* from Mazapil. Dr. Roig states nothing at all about his own material except for four measurements which he gives at the beginning. One not familiar with Burckhardt's monographs, or not having them at hand for constant comparison, would have no way of telling whether he were reading a new description of a Cuban ammonite or an old description of one from Mexico. It is only fair to state, however, that Dr. Roig labored under many difficulties, such as inadequate library facilities, lack of good collections of type material for comparison, the incompleteness of his own specimens, many of which could not be identified, and especially the fact that his own training had been primarily in medicine rather than in palæontology. His interest in natural history led him to collect vertebrate and invertebrate fossils and to make known to the scientific world some of the

¹Roig, Mario Sanchez. 1920. La Fauna Jurásica de Viñales. Republica de Cuba, Secretaria de Agricultura, Comercio y Trabajo, Boletín Especial, 61 pp., 23 plates.

important organic remains of the Jurassic of western Cuba. To the naturalists of Cuba and to others who do not have ready access to Burckhardt's monographs, the careful translation of the protographs from French into Spanish will be very useful, and I know, from a personal communication, that Dr. Roig made the translations with the feeling that he was rendering a service to his Cuban and Spanish readers to whom original sources in other languages were not so available as they were to him.

Brief announcements of the stratigraphy and correlation of the Jurassic formations of Cuba were given before the Palæontological Society of America at the Baltimore meeting in 1918¹ and before the Geological Society of America at the Boston meeting in 1919.² Certain palæontological studies of the Cuban ammonites have been incorporated in a short paper originally presented at the Baltimore meeting above referred to.³

In the description of the ammonites of Cuba I have employed the nomenclature first proposed by Hyatt⁴ and later added to by J. P. Smith.⁵ Most writers on this group of invertebrates are in the habit of giving a few shell measurements and ratios for adult specimens or else they give a set of measurements for several specimens of different sizes of the same species and then make certain general statements about observed trends in shell proportions. It is well known that all ammonites change in proportions in successive stages of development but accurate quantitative data is seldom given. I have, therefore, in describing the ontogeny of the Cuban species, given actual shell measurements and calculated certain significant ratios for as many stages of growth in individual conchs as the preservation of the specimen would permit. At any point on the shell six measurements are sufficient for the determination of the size and form of the conch, these being the diameter (*d*), the height of the whorl measured from the venter to the line of involution with the preceding whorl (*h. i.*), the height measured from venter to the impressed zone (*h. i. z.*)—a measurement which can be made only when one has an oral cross-section—the height of the whorl above the preceding

¹Brown, Barnum and O'Connell, Marjorie. 1919. Discovery of the Oxfordian in Western Cuba. Bull. Geol. Soc. Amer., XXX, p. 132 (abstract). Presented Dec., 1918.

²O'Connell, Marjorie. 1920. Further Studies on the Jurassic of Cuba. Bull. Geol. Soc. Amer., XXXI, p. 136 (abstract). Presented Dec., 1919.

³O'Connell, Marjorie. 1919. Orthogenetic Development of the Costæ in the Perisphinctinae. Amer. Journ. Sci., XLVIII, pp. 450-460, 2 figs. Presented before the Palæontological Society of America, Dec., 1918.

⁴Hyatt, Alpheus. 1894. Phylogeny of an Acquired Characteristic. Proc. Amer. Phil. Soc., XXXII, No. 143, pp. 349-647.

⁵Smith, J. P. 1913. Chapter on Cephalopods in Eastman Translation of Zittel's 'Text-Book of Palæontology.'

whorl ($h. p.$) obtained by measuring the vertical distance from the venter to the line of involution of the preceding whorl, the width of the whorl (w) or the greatest thickness between the lateral faces, and the width of the umbilicus (u). These measurements are all given in millimeters. From these may be calculated the shell proportions which vary with growth, that is, the allometric ratios. They are $\frac{h.i.}{d}$, $\frac{h.i.z.}{d}$, $\frac{w}{d}$, $\frac{w}{h.i.}$, $\frac{u}{d}$, and $\frac{h.i.}{u}$.

DESCRIPTION OF SPECIES FROM THE OXFORDIAN

PERISPINCTES Waagen

In the *Perispinctinae* the costæ have a characteristic arrangement into groups or bundles, there being one long costa passing from the line of involution to, and usually across, the venter, while one, two, three, or sometimes more, shorter costæ branch off from the long one. At repeated intervals on the conch there is a smooth groove or constriction occurring usually after every three to seven bundles of costæ. A detailed study of all of the Cuban specimens belonging to the genus *Perispinctes* showed that in each sector of the whorl bounded by two constrictions, or sphincters, the succeeding groups of costæ vary one from another, there being certain definite trends in the development of individual costæ as well as in their arrangement into groups. From the ontogeny of several of the species, it appears that in the earliest stages the conch is smooth; then constrictions develop; and finally simple, unbranched costæ appear, filling in the spaces between constrictions. The details of the time of appearance of these morphological features will be found below (pp. 650, 676) under the description of *Perispinctes cubanensis* and *P. plicatiloides*. The simple costæ soon become branched. The process of branching expressed in terms of growth seems to indicate that the mantle of the animal grew more rapidly forward on the ventral region than on the sides and consequently it was thrown into folds more rapidly on the ventral and ventro-lateral regions than on the dorso-lateral regions. Thus, while a single fold in the mantle at the umbilical margin was sufficient to take up all the surplus forward growth of the mantle, two, three, or more folds were required to take up the growth on sides and venter. The position of these folds is shown in the conch by the arrangement of the costæ, which are nothing more than the shell expression of the form of the soft parts of the animal.

In order to have a uniform and simple way of referring to the various costæ I have adopted the following system of nomenclature. The conch is divided into sectors bounded by the grooves or sphincters, for which

reason I designate them intersphincterial sectors. At the beginning of each is a single, simple costa, usually a little more pronounced and thicker than the others and this is continuous across the venter, where it is often, and in adult specimens generally, double, there being no actual bifurcation but rather a thickening and broadening with a dividing line passing longitudinally across the ventral portion of the costa. This first and distinctive costa bounding each sphincter orally I have designated the *orad* or *o* costa, Fig. 1. So far as the Cuban species are concerned this costa never marks the beginning of a triad of costæ but always appears alone and is then followed by the typical triad groups; and it seems to be a rather universal fact in all species of *Perisphinctes*

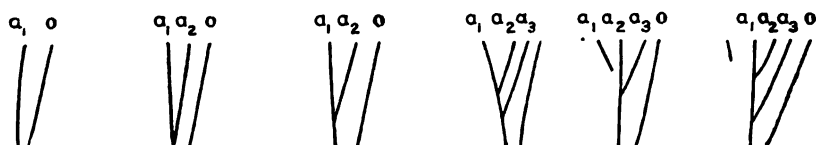


Fig. 1. Diagrammatic sketch of the mode of development of costæ in the genus *Perisphinctes*, showing the origin of diad and triad groups and of intercalated costæ.

that the first costa in any intersphincterial sector is simple, with at most a ventral branching, and is succeeded by the more complex triads or bundles of costæ. On the apicad side of each sphincter is a complex system of costæ consisting of a single continuous costa (the *apicad* or a_1 costa) passing from the umbilical suture on one side of the whorl uninterruptedly across the venter to the suture on the opposite side. From this costa there diverges at a point near the line of involution a second costa (a_2) which is directed orad. With the growth of the conch the point of divergence moves ventrad and eventually a new costa (a_3) develops, diverging from a_1 at the line of involution. As the point of divergence of a_2 from a_1 migrates ventrad, the maximum strength or thickness of the a_1 costa passes in its ventral portion to a_2 while the ventral part of a_1 is separated off and finally becomes a free intercalated rib, passing apicad and out of the group of costæ definitely bounding the sphincter.

The letters a_1 , a_2 , and a_3 are, therefore, used to designate the costæ in the same relative position to the sphincter, a_1 being in every case the first continuous costa apicad of the sphincter. The process of costal development is thus shown diagrammatically in Fig. 1.

***Perisphinctes cubanensis*, new species**

Plate XXXIV, Figures 1 and 2

I have before me three fairly complete specimens of *Perisphinctes* which show the following range in maximum diameter: 50.7 mm., 65 mm., and 86.57 mm. The character of the final whorl of each specimen differs so markedly from that of the remaining two in form, size, and number and arrangement of costæ that probably each specimen, if found in separate localities, would be described as a distinct species. Yet a careful study of the ontogeny of each conch has shown that all three specimens are closely related and that two of them represent specializations in given directions from a simple more generalized type, which I have selected as the holotype of *Perisphinctes cubanensis*, new species (A. M. N. H. No. 18556). The other two specimens I have designated as mutations α and β (A. M. N. H. Nos. 18557 and 18558, respectively). I have called these specialized individuals mutations in order to indicate that the modifications, whether allometric or rectigradational, are in given directions, or orthogenetic, yet I cannot be certain, from the material so far studied, whether they are true mutations in the Waagen sense showing modifications in successive horizons or whether they are variations in the Waagen sense (submutations of Grabau) showing modifications in one horizon. Since the Viñales fauna comes from nodules which contain species from two zones of the Upper Oxfordian, the three individuals under discussion might be either mutations or variations, and I have called them by the former name that there might be no confusion with the ordinary usage of variety, a term which is laxly employed and carries with it no implication of orthogenetic development such as is shown in these specimens.

The holotype of *Perisphinctes cubanensis* shows the greater part of six volutions, on three of which portions of entire whorls, including the venter, are visible. Very little of the shell is preserved, so that all of the characteristics and measurements noted below are for the internal mold only. Nothing can be learned of the embryonic stages of development because the protoconch is absent, nor is it possible to determine the exact position of the earliest conch stage. For this reason, in counting the number of volutions, I have arbitrarily started at the first point in the umbilicus where a whorl rises out of the central, limey matrix which conceals or replaces the protoconch. This point almost certainly does not mark the precise beginning of the first conch volution but is very close to it and serves as a convenient point of reference from which to count the

successive volutions. Since this form is monotypic, I have no additional specimens to break down for studying the protoconch and early epembryonic stages of growth.

FORM AND PROPORTIONS.—The shell as a whole is rather compressed, giving the whorls an oval cross-section (except for the impressed zone), which, however, does not show any angularity at the umbilical shoulder nor along the ventral margins. The umbilical shoulder is always pronounced, though rounded, and there is thus produced a distinct umbilical zone. On the sixth volution where the whorl is more compressed and the shoulder consequently more distinct the distance between the line of involution and the point of greatest thickness of the whorl is 6.3 mm. It is highly probable that the earliest whorls were circular in cross-section (except for the dorsal in-bending of the curve caused by the impressed zone), since the ratio of width to height at the end of the third volution is 0.89, the trend in succeeding volutions being toward a smaller ratio, which shows that if at any time in the ontogeny the whorl was as wide as high, that is with a ratio of 1.00, it must have been before the third volution. In the holotype of *Perisphinctes cubanensis* the whorls increase regularly in height, having approximately the same ratio to the diameter throughout the ontogeny, for the greatest range is from 0.33 to 0.39 (see third column in Table 1). Because the increase in height is fairly constant and not progressively greater, involution is not extreme and there results a broad umbilicus which in the early whorls is approximately as broad as the aperture is high but in the later stages slowly becomes relatively broader, as is shown by the decrease in the ratio $\frac{h.i.}{u}$ from 1.00 to 0.89 (see columns 2 and 11, and 3 and 13 in Table 1).

In the early shell the width of the whorl is about one-third the total diameter, but this ratio decreases (column 9) so that at the end of the specimen the width is only one-quarter of the diameter, showing that there is a relative decrease in breadth as compared to diameter, as well as a decrease when compared to the height of the whorl. All of these progressive allometric changes in the ontogeny are set forth in Table I.

TABLE 1.—Allometric Changes in *Perisphinctes cubanensis*, new species

<i>d</i> mm.	<i>h.i.</i> mm.	<i>h.i.</i> <i>d</i>	<i>h.i.z.</i> mm.	<i>h.i.—</i> <i>h.i.z.</i> mm.	<i>h.i.z.</i> <i>d</i>	<i>h.p.</i> mm.	<i>w.</i> mm.	<i>w.</i> <i>d</i>	<i>w.</i> <i>h.i.</i>	<i>u.</i> mm.	<i>u.</i> <i>d</i>	<i>h.i.</i> <i>u</i>
1	2	3	4	5	6	7	8	9	10	11	12	13
22.03	8.75	0.39	.....	.....	.....	11.00	7.80	0.35	0.89	8.80	0.39	0.99
33.56	12.40	0.37	9.88	2.52	0.29	15.78	9.68	0.29	0.78	11.74	0.35	1.05
55.00	21.40	0.38	.....	.....	.....	26.90	16.30	0.29	0.76	20.50	0.37	1.00
65.89	24.30	0.36	19.35	4.95	0.29	31.60	18.52	0.28	0.76	24.98	0.38	0.97
83.47	27.62	0.33	22.40	5.22	0.26	37.27	20.90	0.26	0.75	29.30	0.40	0.94
86.57	29.78	0.34	23.92	5.76	0.27	39.60	21.42	0.24	0.72	33.39	0.38	0.89

COSTÆ AND SPHINCTERS.—In the earliest observable nepionic stage the conch is smooth, showing neither costæ nor constrictions. At the end of one and a quarter volutions the first constriction or sphincter appears, the umbilicus here being 1.79 mm. wide. On the remaining three-quarters of the second volution there are two more constrictions, but no costæ are discernible until one and three-quarters volutions, although they probably appear at about one and a half volutions, since apicad of that position the whorls are still smooth, as shown by the surface of a few remnants of actual shell, while where the costæ are first seen they are already well developed. The critical area, unfortunately, is destroyed. The costæ appear just apicad of the third constriction, the umbilicus here being 3.30 mm. wide and the whorl 5.00 mm. thick. It is to be noted that the appearance of constrictions is independent of the formation of costæ, since the former appear earlier than the latter in the ontogeny, and yet, once the costæ begin to develop, they always follow a definite plan of formation which heralds the appearance of a constriction and the costæ never have this particular arrangement without being followed by a constriction nor, on the other hand, does a constriction ever appear which is not preceded by costæ which are arranged in a different manner from that observed in intersphincterial areas. Thus, while the lines of growth are parallel to the costæ, the constriction diverges pronouncedly from the direction of the principal costæ, which indicates a marked ventral growth of the shell prior to the formation of

each constriction. This law holds throughout the ontogeny of the holotype of the species and for the two mutations and has also been observed in other species.

The arrangement of costæ on either side of the third constriction is shown in Fig. 2. On the apicad side of the constriction a rather coarse costa (a_1) appears, its point of origin being upon the umbilical shoulder, which is pronounced though rounded. This costa is strong and thick and gives off a branch (a_2) near the line of inclusion. The a_3 costa diverges near to the umbilical suture of the second volution and is directed orad diagonally across the whorl, parallel to the o costa which is simple and not very prominent. Whether or not the a_3 costa gives off a branch on the ventral or lateral ventral zone cannot be determined because of the involution of the whorls. Thus the fundamental plan of sphincterial delimitation by the costæ may be briefly described as follows. A simple orad costa and a complex apicad system in which costæ a_2 and a_3 are developed, with the latter simple (or branched?). The a_1 and o costæ are strong, while the branches of a are weaker. As a result, the two strong costæ enclose a triangular area which widens ventrally and in which are situated the weaker costæ and the constriction. The last of the branches of the a system, in this case a_3 , and the o costa are always

parallel and bound the constriction on either side. This fundamental plan can be observed in each sphincterial costal group in this species and its mutations but in the latter onto-stages of the holotype and in the earlier ones of accelerated mutations certain modifications take place leading to increased complexity along definite lines. The modifications so far observed are in three directions: one, through the development of additional orad branches; two, through the ventral migration of the point of divergence of the older branches (a_2 , a_3 , etc.); and, three, through the increased obsolescence of the dorsal portion of the last-formed costa on the apicad side of the constriction, that is, usually, a_3 , or, in cases of acceleration, a_4 , until it appears as a free intercalated costa.

The third volution of the conch contains at least three constrictions, but the state of preservation does not permit more accurate observation. However, the specimen does show that between the o costa

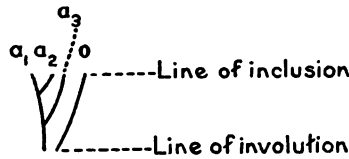


Fig. 2. Arrangement of costæ on the second volution of *Perisphinctes cubanensis*, holotype A. M. N. H. No. 18556, showing grouping on either side of the third constriction.

of the third constriction (counting from the earliest one seen) and the a_1 of the fourth, there are six intersphincterial costæ, the branching of which is not exposed, and the same number exists between the fourth and fifth constrictions, but between the fifth and sixth the number cannot be determined.

Half of the fourth volution is visible in its entirety because the later whorls are broken off. Complete constrictions are thus exposed and the character of the ventral costæ may be determined. What appears to be the eighth constriction of the conch occurs just orad of the beginning of the fourth volution at a point where the umbilicus is 8.38 mm. wide, the whorl 5.89 mm. thick and 5.80 mm. high. There is a single straight costa (o) on the orad side of the constriction (Fig. 3). On the apicad side a single, low, coarse costa (a_1) arises on the umbilical shoulder. At a height of 3.12 mm. from the line of involution the a_2

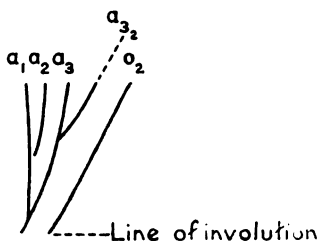


Fig. 3. Arrangement of costæ at beginning of fourth volution of *Perisphinctes cubanensis*, holotype A. M. N. H. No. 18556, showing increased complexity in grouping produced by repeated bifurcations.

branch diverges from the a_1 costa; a_3 in its dorsal portion merges into a_1 , showing that it was formed very soon after a_2 . At a height of 3.81 mm. from the line of involution a_3 bifurcates, the orad branch, passing across the venter approximately parallel to o . On the venter this branch of a_3 becomes broader than other members of the a system so that it appears as a slightly prominent lip emphasizing the apicad boundary of the constriction. The a_3 costa is strong on the dorso-lateral area until branching takes place, and then

the branch becomes strong so that there is produced the appearance of an almost continuous strong costa on the apicad side of the constriction.

On the first half of the fourth volution, there are four constrictions, of which the one just described in detail is the first. Between the o costa of the eighth and the a system of the ninth constriction there are three lateral costæ, the first of which is simple with an apicad deflection in its ventral portion, the other two having one branch each which gives an appearance of bifurcation. Between the ninth and tenth constrictions are four intersphincterial¹ costæ, all of which are branched once, and the same is the case between the tenth and eleventh, while there are only three between the eleventh and twelfth constrictions, the costæ thus

¹It is to be remembered that by this term I designate the lateral costæ between the o of one constriction and the a system of the next succeeding one.

showing a certain amount of variation. There are three constrictions on the second half of the fourth volution, which is the last complete whorl on the holotype and which ends at a diameter of about 31.8 mm., the shell being broken away just at the point where the fifteenth constriction should appear so that only portions of the fifth and sixth volutions remain. On the last half of the fifth, which ends at a diameter of about 65.8 mm., there are four constrictions, twenty primary costæ arising in the umbilical zone and fifty-five ventral costæ, including the *o* and *a* as well as the intersphincterial costæ. Between the first two constrictions the lateral costæ are either singly or doubly branched; between the last two all are doubly branched giving the appearance of trifurcation or intercalation. The arrangement of the costæ on the last quarter of the whorl is shown in Fig. 4.

On the last half of the fifth whorl the costæ are well preserved on both sides and on the venter and it will be noted that they are arranged in groups of three, in which one costa passes from venter to dorsum and is strong, while two are developed on the venter only and are less pronounced (Fig. 5). Furthermore, a careful study of each group shows that there is a steady orad progression of the strong costa from group to group. Thus, on the right side of the shell the first group (I) beyond the

o costa of intersphincterial group M shows costa 1 strong and continuous and deflected apicad toward the venter, with 2 and 3 weaker, 2 being attached, 3 directed towards 1, but free. In the second group (II) the greatest strength has passed to costa 2, while the point of divergence of branch 1 is weak and 3 has approached 1 dorsally. In group III the first costa has become free, 2 is still strong but bent backward, while 3 has become fully attached to 2. In the fourth group (IV), which is the *a* system of the next constriction, 1 has separated off and appears as a free "intercalated" costa, 2 is still directed toward 3 but is free, while the greatest strength has passed to 3 which bends apicad so much that, with additional growth on the ventral portion, two new costæ appear in quick

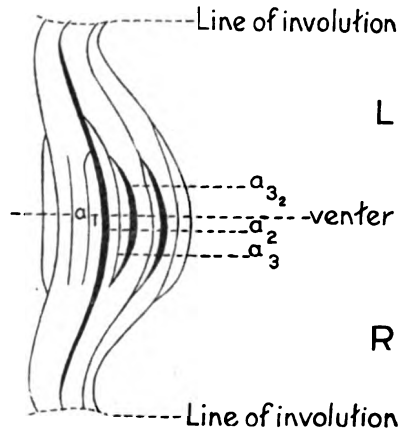


Fig. 4. Arrangement of costæ on last quarter of fourth volution of *Perisphinctes cubanensis*, holotype A. M. N. H. No. 18556, showing differential acceleration of costæ on right (R) and left (L) sides of whorl and the origin of free intercalated costæ, *a*₁, appearing intercalated on right side, but still being joined to *a*₂ on the left side.

succession. Of these, 4 is parallel to 3 except at its dorsal end where it approaches 3 and, if prolonged, would join it about midway of the lateral face of the whorl; 5 bends more strongly toward 4 and is shorter than it, but on the left side 5 actually joins 4.

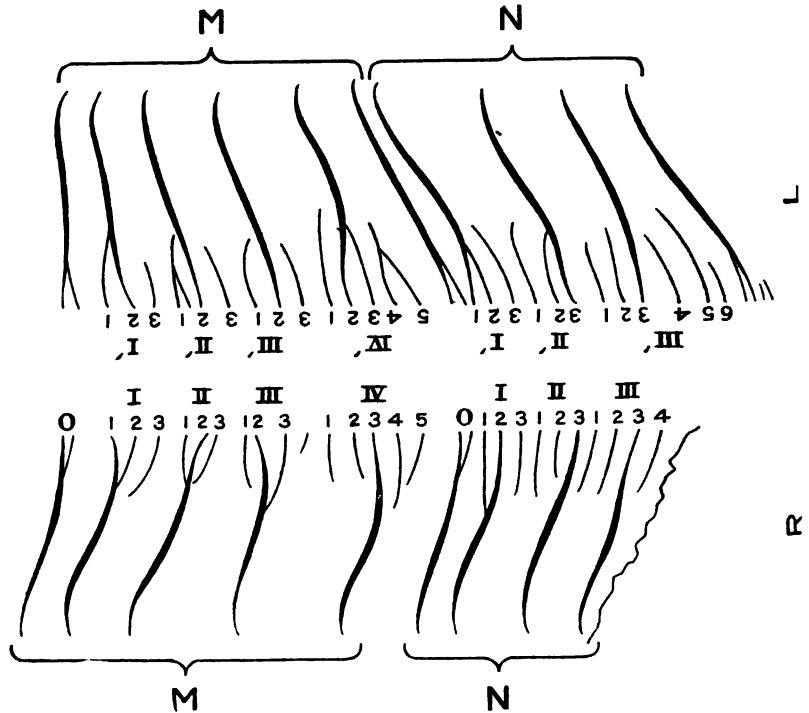


Fig. 5. Arrangement of costae on last half of fifth volution of *Perisphinctes cubanensis*, holotype A. M. N. H. No. 18556, showing grouping into triads, differential acceleration on right (R) and left (L) sides of whorl, the orad migration of strength in each triad, and the formation of intercalated costae.

The left side of the shell shows less acceleration in the orad migration of the strong costae. Thus group I' has 1 and 2 united as in group I but 3 is entirely free, not even pointing towards the strong rib. Group II' shows costa 1 just becoming free as in group II on the right side, but costa 3 is still nearly parallel. The third costa of groups I' and II', though appearing parallel to the second costa in each case, would, if

continued dorsally, join this costa near the line of involution. The third costa of group III' in its dorsal end bends toward the second costa, which is strong, and would join it, if continued, much farther from the dorsum than the third costa of the two preceding groups. This, then, may be interpreted as a progressive ventral migration of the point of divergence of the third from the second costa in the successive groups, even though, at the point of divergence, the shell is not thrown into a costal elevation. The third costæ of groups I, II, and III on the right side show this same progress further along, costa 3 of group I corresponding essentially to 3 of group III', while costa 3 of group II very nearly joins costa 2 and the corresponding costa of group III actually does join. In this respect, then, the three groups of the right side represent further stages in acceleration beyond the first three groups of the left side. The fourth group (IV') of the left side or the *a* system is less accelerated than the group IV on the right side, costæ 1, 2, and 3 of IV' corresponding essentially to 1, 2 and 3 of group III on the opposite side. Costa 1 of group IV' is free; 2 is the strong costa but is deflected apicad ventrally; 3 joins 2 at the point of deflection; 4 is still free and essentially parallel to 3; and 5 turns towards 4 but does not join it. In group IV on the right side, as already stated, costa 4 joins 3, and 5 joins 4. Again, if we prolong costa 4 in group IV' it would join the strong costa near the line of involution and costa 5 would join 4 much more dorsad than is the case in group IV on the right side. Thus again is shown the ventral migration of the point of departure of the costæ on the more accelerated side, a mode of progressive change already referred to as characteristic of the orad costa of successive *a* systems.

In the intersphincterial sector N there are only three groups of costæ instead of four, but these on the whole are more accelerated along the lines already discussed than are the corresponding ones in sector M (Fig. 5). This is not the case, however, with the first group of the right side of the N system, which is essentially like the first group of the M system, but the second group of N is parallel to the apicad part of group IV in M; that is, costæ 1, 2, 3 of N-II have the same relation to one another as costæ 1, 2, 3 of M-IV. Group N-III, however, is more accelerated than any group in M, for the three costæ are parallel, 1 and 2 being short and free while 3 is strong but not deflected. N-III is the *a* system of the constriction terminating N, on the right side, but only costa 4 is preserved, this bending toward 3 but not joining it, being, therefore, more accelerated than the corresponding costa of group M-IV. On the left side of the shell, however, the series is complete, groups I' and

II' being practically the same as their corresponding groups on the right side, though slightly less accelerated. Costa 4 of group III' has the character of 4 of group III, but two additional costæ, 5 and 6, appear. Costa 5 is longer than 4 and parallel to it and would, therefore, if prolonged diverge from costa 3 nearer the line of involution. Costa 6 is short, its dorsal end bending towards 5 but not joining it. Taking costæ 3, 4, 5, and 6 of this group, and the corresponding lines of growth of the shell which are always parallel to the costæ wherever preserved, we see here an accelerated forward growth of the ventral side of the shell, this being always more rapid than the forward growth of the shell as a whole, a fact which explains the arrangement of the costæ of this group. This accelerated forward growth comes to an end with the formation of the constriction, as already pointed out.

The *o* costa, which in all the earlier whorls is a simple, thick costa, becomes compound somewhere on the fifth volution, for it so appears at the constriction at five and a half volutions and becomes progressively more marked. This compound character is due to an interruption in the formation of the costa, the mantle fold, of which it is the shell expression, having for a short time contracted on the venter, giving rise to a groove, after which it expanded to the usual size and a costa of normal strength was formed. On the holotype these two parts of the compound costa never become independent branches but, because they are incipient branches and so appear at a rather early stage in mutation β , I have called them the o_1 and o_2 costæ.

The only portion of the sixth whorl preserved is that from five and a quarter to five and a half volutions, that is, from a diameter of 78.6 mm. to one of 86.5 mm. In this space there are two constrictions which I shall designate *x* and *y* since I do not know their exact numerical position in the ontogeny. There are three groups of costæ in the intersphincterial region X (Fig. 6). Group X-I on the right side corresponds almost exactly with the stage of development shown in group N-II, the acceleration being so great that instead of the maximum strength being found in the first costa as it is in group I in M and N, it has already passed to the third. Costæ 1 and 2 in X-I are both free but directed towards 3, while in the next group (II) they appear to be almost parallel to 3. In this respect X-II corresponds to the first three costæ in N-III. Group X-III is accelerated beyond anything observable in the N area and undoubtedly corresponds to some stage exhibited in the shell during the early part of the sixth volution, which portion, unfortunately, is missing. This last group in X is the complete *a* system terminating sector X and

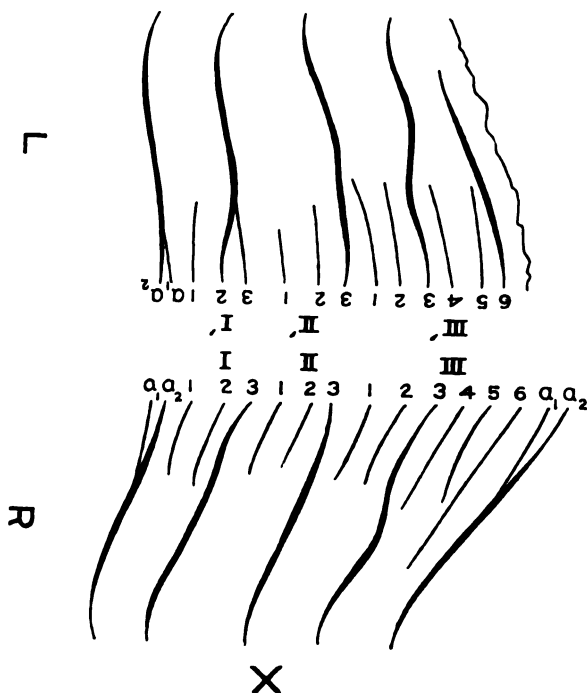


Fig. 6. Arrangement of the costae on first half of sixth volution of *Perisphinctes cubanensis* showing adult costal grouping, each triad consisting of one long, strong costa and two short, weaker, free, "intercalated" costae. Right side (R) more accelerated than left side (L).

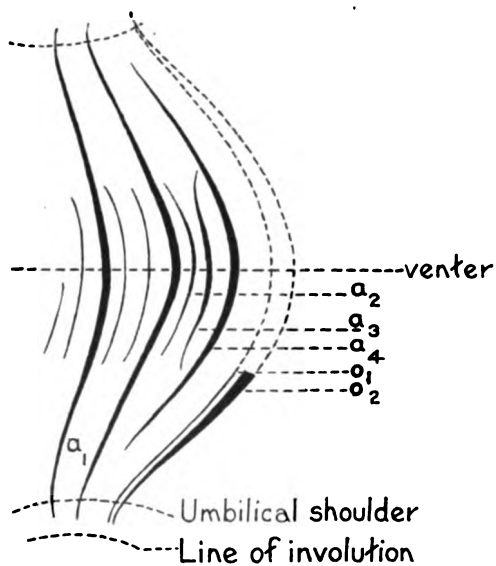


Fig. 7. Tracing from the holotype of *Perisphinctes cubanensis* showing the last costae on the final whorl and the adult costal delimitation of the last constriction. Note that the new costa (a_4) begins near umbilical shoulder; a_2 and a_3 have become obsolescent dorsally appearing as free, "intercalated" costae. Same as group III in Fig. 6, a_1 = costa 3, a_2 = 4, a_3 = 5, a_4 = 6.

contains six costæ, of which the third is the strongest (Fig. 7). Costæ 1 and 2 are essentially parallel, appearing as free "intercalated" ventral costæ; 3 is deflected apicad ventrally so that the short branch 4 is in line with the dorsal portion of 3 and would join it if prolonged. Costa 5 is short and directed toward, but not joined to, 6. In N-III' the sixth costa is short while 5 is longer, extending half-way towards the dorsum, while in X-III and X-III' the strength has passed orad to 6 which is the longer costa and which extends three-fourths of the way towards the dorsum. On the left side of the whorl the first of the three X groups is slightly less accelerated than on the right, costa 2 is a little stronger than 3 and the line of continuous growth is along the former not the latter as on the right side; 3, however, is united to 2. Group X-II' is practically identical with X-II, as is also X-III' with X-III. On the orad part of the left side some of the shell is preserved towards the dorsum and the growth-lines are clearly shown paralleling the long and strong 3 costa and the shorter, weaker 6. In the shell it is seen that the sixth costa approaches much nearer the dorsum than would be supposed from what can be observed in the internal mold, which suggests that in later whorls this will become a normal long costa.

These details concerning the mode of costal development throughout the ontogeny of this species bring out the following interesting facts: (1) the costæ develop in a definite and progressive manner throughout the entire conch; (2) the sphincters divide the conch into sectors in each one of which the costæ develop with mathematical precision and increasing complexity, the arrangement at the beginning of each sector repeating that at the middle or end of the preceding one, while the costæ at the end of each sector are more advanced than those at the end of the preceding one; the definite trends in development are thus progressive in their entirety, but at repeated intervals in the life of the animal there was a resting period, a slight repetition and then a further advance; (3) there was differential acceleration on the right and left sides of the animal, showing that the mantle folds were seldom absolutely bilaterally symmetrical, one side of the mantle having been thrown into folds such as the opposite side had one-quarter or one-half of a revolution before. Yet each side showed the same plan of costal arrangement and though one lagged behind the other the nicety and exactness of their correspondence is truly remarkable. The significance of this clearly demonstrated orthogenetic method of growth is more fully discussed in another paper.¹

¹O'Connell, Marjorie. 1919. Orthogenetic Development of the Costæ in the Perisphinctinae. Amer. Journ. Sci., XLVIII, pp. 458-460.

Having considered in detail the arrangement and number of costæ and the sphincterial costal systems, we may turn to the form and mode of growth of the individual costæ. As we have already observed, the costæ on the first four volutions begin on the umbilical shoulder, but in the last two volutions the point of origin moves dorsally, the *o* costa being, in general, slightly longer than adjoining costæ. In those places on the fifth and sixth volutions where the shell is preserved, all costæ are seen to arise directly from the line of involution, but the internal mold shows the first traces of these same costæ only on the umbilical shoulder, which would lead to the supposition that, were the shell preserved throughout the later whorls, all of the costæ would be found to have their inception at the lines of involution. Throughout the ontogeny the costæ are directed orad at an angle of about 20° to a line passing through the centre of the umbilicus. Since the lateral costæ in general develop parallel to one another, it is obvious that, being on a spiral, if a costa had an orad trend of 20° at any point and the next costa were parallel to it the second would have a direction less than 20° . This is actually the case and the costæ would in time be directed less and less orad, until they became vertical to the whorl and would then bend apicad. But we have seen that prior to the formation of each constriction there is an excessive ventral growth and formation of new costæ so that the general trend is restored. To be more precise, it is only the successive *o* costæ that have the orad inclination of 20° , while the succeeding intersphincterial costæ become progressively less and less inclined until the first costa of each *a* system averages an inclination of only about 15° . The strong apicad reflection of the costæ on the umbilical shoulder is a character which is found in all of the mutations but is not confined to this species. A slight orad inflection at about the middle of the flanks is very generally, though not invariably, present. The primary costæ are most sharp at the umbilical shoulder, becoming less salient and more rounded as they approach the point of branching. On the venter all of the costæ have approximately the same strength, with the exception of the simple or compound *o* costa, which is pronounced not because it is any higher but because it is broader and thicker than the other costæ. Occasionally, too, the last costa of the *a* system is thickened. On the later whorls the most sharp and salient costæ are the longest ones of the *a* systems of the successive constrictions.

Wherever the venter is exposed the costæ in the internal mold show a slight depression or apparent obsolescence on the median ventral line. In some places the costæ are completely interrupted, in others merely

notched, while at the end of the last whorl preserved most of the costæ show no weakening at all in crossing the venter. Where this obsolescence is shown there is produced a smooth, narrow ventral band. The full significance of this feature is discussed below on p. 669, but it may here be stated that the interruption is visible only on the internal mold and that in the few places where the shell is preserved on the venter the costæ show no weakening. The smooth ventral band is, therefore, occasioned by the formation of a ridge on the inner surface of the shell, this ridge being due to excessive shell deposition or an internal ventral thickening which finds no expression in the outer surface.

SUTURES.—As is the case with so much of this Cuban material, the preservation is such that no sutures are shown.

COMPARISON WITH RELATED FORMS.—Since the holotype of this species is almost certainly not the conch of a fully grown individual and since no sutures are shown, comparison with other species is very difficult. It is very closely related to *Perisphinctes durangensis* Burckhardt from the lower beds of the Upper Oxfordian of Cerro del Volcán in Durango, Mexico. Unfortunately, Burckhardt had only a single, fragmentary specimen and his specific characteristics as to form, proportions, and costal arrangement are described from the last two whorls only. The dimensions which he gives are taken at a diameter of 123 mm., while the specimen of *P. cubanensis* shows a maximum diameter of 86.37 mm. Comparisons in actual measurements and in proportions between the two species are, therefore, impossible but the form, cross-section of whorls, costal arrangement, and the mode of development of the costæ bounding the sphincters may be compared and in these respects the two species are very similar.

HORIZON AND LOCALITY.—Lower beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Perisphinctes cubanensis* a. new mutation**

Plate XXXIV, Figures 3 and 4

HOLOTYPE (A. M. N. H. No. 18557).—This mutation is represented by a single specimen which is practically complete, except for one break, through five and a half volutions. The last whorl has been crushed and a certain amount of lateral compression has thus been brought about. Shell remains in only a few places and it is in such a poor state of preservation where it is shown that it is of little value except at the end of the specimen, where a narrow strip shows the mode of growth of one of the costæ.

The conch in form, proportions and amount of involution is so similar to the holotype of *P. cubanensis* that, were it not for differences in the costal and sphincterial development, the two specimens would be considered as the same species, for they differ less from each other in these allometric characters than do many individuals which are unhesitatingly referred to a single species. Unfortunately, it is impossible to make measurements of the young stages, but between the diameters of 39.3 mm. and 65.0 mm. the actual dimensions and proportional ratios are almost identical in the two forms and they show the same directions in development. (Compare Tables 1 and 2.)

TABLE 2. Allometric Changes in *Perisphinctes cubanensis* mutation α

d mm.	$h.i.$ mm.	$\frac{h.i.}{d}$	$h.i.$ mm.	$\frac{h.i.}{h.i.z.}$ mm.	$h.i.z.$ mm.	$h.p.$ mm.	w mm.	$\frac{w}{d}$	$\frac{w}{h.i.}$	u mm.	$\frac{u}{d}$	$\frac{h.i.}{u}$	No. of volu- tions completed
1	2	3	4	5	6	7	8	9	10	11	12	13	14
39.3	15.1	0.38	.....	.....	.....	19.3	13.1	0.33	0.86	13.6	0.34	1.11	$4\frac{3}{4}$
45.5	16.9	0.37	.....	.....	.....	22.1	14.4	0.31	0.85	15.7	0.34	1.06	5
65.0	23.4	0.36	18.8	4.6	0.29	31.8	18.8	0.29	0.81	25.3	0.39	0.92	$5\frac{1}{2}$

It will be noted that the measurements and ratios for mutation α might almost be used as interpolations for *P. cubanensis*: the first two lines of figures in Table 2 would fit in between the second and third in Table 1, while the third line in Table 2 would fit in between the third and fourth in Table 3. There are, however, certain differences due to slight differential acceleration or retardation in the allometrons. For instance, if we take *P. cubanensis* as the standard for comparison, then mutation α shows retardation in the retention, at a diameter of 65 mm. of the shell ratios $\frac{w}{d}$ and $\frac{w}{h.i.}$ which in *P. cubanensis* are found at some diameter between 22 and 33 mm. On the other hand, the ratios of width of umbilicus to diameter and of height of whorl to umbilicus are in mutation α at 65 mm., diameter the same as are found at some diameter between 65 and 83 mm., in *P. cubanensis*. In this respect, then, mutation α is accelerated. These varying rates of change furnish an excellent example of heteroëpistasia.

In costal arrangement mutation α retains a primitive condition, most of the triad groups showing only one free costæ, while in the adult *P. cubanensis* both of the short costæ have become free. The costæ bounding the sphincters in the last whorl of mutation α have the appearance of homologous costæ in the early stages of *P. cubanensis*, the points of divergence of the α costæ not having migrated very far ventrad, while the σ costæ show no tendency toward ventral division. The whole costal plan, as well as the individual costæ, show less acceleration than obtains in either *P. cubanensis* or mutation β .

The internal mold shows a ventral groove the same as in *P. cubanensis* and mutation β and its origin is the same.

The preservation is such that no sutures are shown.

HORIZON AND LOCALITY.—Lower beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Perisphinctes cubanensis* β , new mutation**

Plate XXXV, Figures 1 and 2

HOLOTYPE (A. M. N. H. No. 18558).—The third specimen in this group is rather poorly preserved and the inner whorls cannot be studied, but in its proportions it appears undoubtedly to belong to the *P. cubanensis* series, although the costæ show an acceleration beyond any stage observed in the other forms. While it is impossible to count the inner whorls, it is probable that there are about five volutions represented, judging from the size.

The conch is most like that of mutation α , showing the same proportional deviations from *P. cubanensis* as does that mutation. The amount of involution is approximately the same for all the specimens at the same diameter. In Table 3 are given all of the measurements that could be obtained from the specimen, together with the ratios.

TABLE 3. Allometric Changes in *Perisphinctes cubanensis* mutation β

d mm.	$h.i.$ mm.	$\frac{h.i.}{d}$	$h.i.z.$ mm.	$\frac{h.i.}{h.i.z.}$ mm.	$\frac{h.i.z.}{d}$	$h.p.$ mm.	w mm.	$\frac{w}{d}$	$\frac{w}{h.i.}$	u mm.	$\frac{u}{d}$	$\frac{h.i.}{u}$
1	2	3	4	5	6	7	8	9	10	11	12	13
39.7	14.9	0.37	.....	.....	.....	19.1	12.7	0.37	0.85	13.8	0.34	1.08
44.7	15.9	0.35	.....	.....	.....	21.1	13.2	0.29	0.83	18.1	0.41	0.88
50.7	17.4	0.34	.....	.....	.....	23.9	14.3	0.28	0.82	20.3	0.40	0.85

From these figures we see that, when the conch is 39.7 mm. in diameter, it is almost identical in form with mutation α at a diameter of 39.3 mm. (see Table 2) and, in consequence, the acceleration or retardation in proportions which we noted when comparing mutation α with *P. cubanensis*, hold also for mutation β . But, while at this stage α and β are alike and both differ in the same way from *P. cubanensis* and while both continue as they increase in size to differ in the same directions from the primitive form, β shows a more rapid progress in ratio changes than does α , so that when β is 50.7 mm. in diameter it has very nearly the shell ratios of α at 65 mm. or is slightly in advance.

It is in the costal arrangement that mutation β differs most decidedly from the other two specimens in this group and it is possible that when more material is studied this difference will be found to be great enough to require the separation of this mutation as a distinct species. Even on the fourth volution the costæ show a repeated double bifurcation and once a triple bifurcation, so that the typical triad grouping is frequently interrupted by bundles of costæ arranged in multiples of two. This is well shown at the very end of the holotype in figure 1 on Plate XXXV. The σ -costæ, wherever visible, are markedly double in character on the venter, assuming at an early stage a character which in *P. cubanensis* does not become prominent until the fifth volution. Since there is only a single specimen of mutation β and none of the early whorls are shown nor any sutures, its affinities are a little uncertain except as indicated by the allometric proportions.

HORIZON AND LOCALITIES.—Lower beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Perisphinctes delatorii*, new species**

Plate XXXV, Figures 3; 4a, b, c; 5; 6

1920. *Perisphinctes delatorii* O'Connell. ROIG, La Fauna Jurásica de Viñales, p. 23, Pl. VII, fig. 2.

HOLOTYPE (A. M. N. H. No. 18559).—Portions of six volutions are preserved, but after the second, which is complete, only half or less of each whorl remains. During the preparation of the specimen, which was almost wholly embedded in the tough limestone of one of the nodules, the incomplete later whorls separated from each other so that the entire dorsum and venter of the fifth and sixth and the venter of the third and fourth volutions were exposed. On the first, second, and third whorls the shell is more or less preserved, but beyond these there is only the internal mold, which, however, on the dorsum of the last two

whorls has the shell from the preceding whorls still clinging to it. At three places the conch has broken along septa exposing to view the lobes and saddles.

FORM AND PROPORTIONS.—The first two whorls are smooth, evolute, and rounded on sides and venter. At the earliest point where measurements can be made, that is, in the first quarter of the third volution, the whorl is only five-sevenths as high as wide, the involution is close and the height is considerably more than the width of the umbilicus. The readings recorded in Table 4 show that the following changes in proportion take place in the ontogeny: (1) the ratio of width to height of whorl progressively diminishes from 1.40 at a diameter of 5.70 mm. to 0.84 at a diameter of 67.1 mm.; (2) the ratio of height to diameter also progressively diminishes, passing from 0.44 to 0.32 in the same diameter intervals; (3) the ratio of width to diameter decreases from 0.61 to 0.28; (4) the ratio of width to umbilicus fluctuates, but is greater from a diameter of 35 mm. on than in the earlier stages. In other words, as the conch increases in size it becomes more evolute, passing from a

TABLE 4. Allometric Changes in *Perisphinctes delatorii*, new species

<i>d</i> mm.	<i>h.i.</i> mm.	$\frac{h.i.}{d}$	<i>h.i.z.</i> mm.	$\frac{h.i.}{h.i.z.}$ mm.	$\frac{h.i.z.}{d}$	<i>h.p.</i> mm.	<i>w</i> mm.	$\frac{w}{d}$	$\frac{w}{h.i.}$	<i>u</i> mm.	$\frac{u}{d}$	$\frac{h.i.}{u}$	No. of volutions completed
1	2	3	4	5	6	7	8	9	10	11	12	13	14
5.70 (est.)	2.50	0.44	.....	.....	.....	2.90	3.51	0.61	1.40	2.19	0.38	1.14	2¼
9.50 (est.)	3.80	0.40	3.03	0.77	0.32	5.70	4.86	0.51	1.28	3.60	0.38	1.06	3
13.30	4.90	0.37	.....	.....	.....	6.28	5.80	0.43	1.18	4.49	0.37	1.09	3½
19.00	7.45	0.39	5.39	2.06	0.28	9.34	7.78	0.41	1.04	7.10	0.37	1.05	3¾
26.82	10.18	0.38	7.75	2.43	0.21	12.80	10.31	0.38	1.01	9.30	0.34	0.91	4½
35.1	11.8	0.33	9.80	2.0	0.27	16.3	11.8	0.33	1.00	13.8 (est.)	0.39	0.85	4¾
67.1 (est.)	22.05	0.32	18.65	3.40	0.28	30.5	18.67	0.28	0.84	30.7 (est.)	0.45	0.71	5¾

stage where the whorls are wider than high through one where they are of equal dimensions (at 35 mm.) to one where they are higher than wide. The sides change in outline from rounded to compressed, with the result that the line of greatest width of whorl passes from the middle in the young conch towards the dorsum in the adult. It will further be observed from the data in the table that all of the ratios change more rapidly in the young than in the adult conch; thus, taking the range of the four ratios $\frac{h.i.}{d}$, $\frac{w}{d}$, $\frac{w}{h.i.}$, and $\frac{h.i.}{u}$ from the diameter of 5.70 mm. to that of 35.1 mm. and comparing these with the corresponding ranges from 35.1 mm. to 67.1 mm., we have the following:

Range in Diameter	Range in Ratio of $\frac{h.i.}{d}$	Range in Ratio of $\frac{w}{d}$	Range in Ratio of $\frac{w}{h.i.}$	Range in Ratio of $\frac{h.i.}{u}$
5.7—35.1	0.44—0.33	0.61—0.33	1.40—1.00	1.14—0.85
35.1—67.1	0.33—0.32	0.33—0.28	1.00—0.84	0.85—0.71

COSTÆ AND SPHINCTERS.—The first two whorls are smooth and, so far as the preservation permits of accurate observation, there are no constrictions until near the completion of one and three-quarters volutions. Here, and again at about one and seven-eighths volutions, occurs a pronounced constriction with a strong orad trend ventrally. We are able to establish beyond any doubt the early character of the whorl in this species, because the specimen shows the entire sides and venter of the first quarter of the third volution, and—a thing which is rare in this material—the shell is preserved. At the very beginning of the volution the shell is smooth and then, almost immediately, appears the third constriction which is most profound where it crosses the umbilical zone and shoulder and least marked on the venter. The whorl here is 3.2 mm. wide and 2.3 mm. high, while the umbilicus is 2.8 mm. in width. Bounding the constriction on the orad side is the first costa of the conch, thick and strong on the venter, weaker on the sides and not discernible dorsad of the umbilical shoulder. Between the third and fourth sphincters the venter and sides of the whorl are smooth except for the fine growth-lines which can be clearly seen and which, from their strong orad trend, indicate that the ventral growth was very much in excess of the dorsal, as is also shown by the fact that between these two constrictions the ventral arc measures 4 mm., the dorsal only 1 mm. On the orad side of

the first *o* costa the shell along the umbilical shoulder is at first as smooth as it is on the sides and venter and then there appear three gentle undulations which, though faint, are distinct and show the first stages in the formation of intersphincterial costæ. They are only 0.7 mm. in length and fade away imperceptibly towards the venter.

We thus see that the costæ are not at first continuous, nor should we, indeed, expect them to be from the very method of their development, for the costæ are but the outer and visible expression in the shell of the inner and now invisible configuration of the mantle of the living animal. The appearance of costæ means that a transverse oral fold had formed at this stage in the growth of the animal. Such a fold, repeated at regular intervals throughout the life of the individual, seems in the beginning to have arisen as a mechanical adaptation, although after it had become impressed as a fixed character it continued to form even after the mechanical necessity had largely ceased to exist. We have noted that in the third volution the shell on the venter was increasing very rapidly, while on the dorsum the rate was only one-fourth as great. On the venter the shell is smooth, indicating that the rate of shell-building just kept pace with that of the growth of the abdomen. If we suppose that on the umbilical margin the rate of shell-building lagged behind the rate of growth of the dorsum of the animal, then we would have, in the mechanical necessity for the crowding of the soft parts into the dorsal shell region, an adequate explanation of the formation of short folds to take up the surplus in growth. The explanation is suggested as one which is adequate to account for the facts observed and as one which is in accord with similar phenomena observed in other Mollusca, but, until more specimens have been studied, no general applicability can be claimed for it in other species. It is evident that folds formed in this manner for the purpose of enabling the animal to crowd its soft parts into a shell which was too small on the back would give rise to costæ which, if we read their origin aright, would not pass across the venter.

The temptation is strong at this point to venture a generalization concerning the origin of costæ in general, namely, that the point of inception is in the umbilical zone and that costæ are at first short and developed only on the dorsal portion of the sides whence, during the ontogeny, they extend ventrad and may in time cross the venter, when they will appear as complete costæ. This generalization is borne out by two other lines of evidence, the first phylogenetic, the second ontogenetic. The most primitive species of the Lower Jurassic (Liassic) genus *Psiloceras* is characterized in the adult by simple unbranching costæ which

arise on the umbilical shoulder, are strong on the sides, and become faint or obsolescent on the venter. In this form which Hyatt has called *Psiloceras planorbe* var. *plicatum*¹ we have very possibly the ancestral type of the genus *Perisphinctes* and we see that the costæ which are characteristic of the neanic and ephebic stages in *Psiloceras* have the form and mode of development which they display in the early part of *Perisphinctes* where, in less than half of a volution, the conch passes from the smooth to the regularly ribbed form, showing thus in its ontogeny a recapitulation of the characters of the early Jurassic form. If, as has been thought, *Psiloceras* is a decadent genus and not a primitive radical of several groups, we should look for some *Psiloceras*-like ancestor of the *Perisphinctinæ*. The ontogenetic evidence mentioned above as being in support of the general statement regarding the mode of formation of costæ is found in the life history of *Perisphinctes cubanensis* and of each of its mutations. At all times when new costæ appear they are first formed as part of the *a* system, and they always begin near the umbilical suture or shoulder as we have repeatedly seen.

Beyond the fourth constriction, that is, at about $2\frac{3}{8}$ volutions, the shell is smooth for a short distance and then the costæ appear, stronger and slightly longer than in the preceding intersphincterial area, but not yet reaching the venter, nor even, indeed, the line of inclusion. The development is similar between the fifth and sixth constrictions, the whorl being smooth immediately orad of the *o* costa and then the costæ appear, faint at first but increasing in strength until the *a* costa is reached. Here, on the apicad side of the sixth constriction, at about three and a half volutions, there is observable the first costal branching. The *a*₁ costa is exceptionally thick on the umbilical shoulder and at a height of about 0.6 mm., from the line of involution *a*₂ diverges at a small angle and, judging from the strength of this branch and of *a*₁, the two pass across the venter. The formation of this new costa, not parallel to but divergent from the simple intersphincterial costæ, brings about a reduction in the differential acceleration of growth on the venter as compared to that on the dorsum, so that the angle at which the constriction bends orad is smaller than it had been up to this point. This phenomenon is, perhaps, to be explained as due to a slowing up of the shell-building power on the venter without a corresponding decrease in the abdominal growth of the animal, with the result that, confronted by the necessity of keeping itself within a shell that was not growing as fast as it was, the animal had

¹Genesis of the Arietidæ, 1889, p. 121, Pl. 1, figs. 5. 6.

to form an additional fold in its mantle and this fold apparently extended across the venter from the very beginning of its development and did not, like the earlier folds which took up the surplus growth along the umbilical margin, die out on the sides. After the seventh constriction the specimen is broken so that it is impossible to give the absolute number of the constrictions on the later whorls.

At four and a half volutions the *a* system has the following arrangement: a_1 is simple and strong; at the umbilical shoulder a_2 which is less salient diverges from and quickly becomes parallel to a_1 , while ventrally the former even slightly approaches the latter. Costa a_3 diverges from a_2 at 4.0 mm., from the line of involution, appearing as a bifurcation of a_2 . From the compound a_2 - a_3 stem, a_4 diverges at 3.4 mm. from the umbilical suture and does not attain the same strength as the other *a* costæ until it reaches the venter. All of the costæ of the *a* system become of equal strength in crossing the venter, but on the sides a_1 is the strongest and the later-formed ones are weaker.

In the succeeding intersphincterial region the first costa following *o* is simple, the second, third, and fourth are bifurcatingly branched. In the second the orad branch is slightly stronger and bends forward; in the third the strength is a little greater in the apicad branch, with the point of divergence of the orad branch weakened, the continuity being on the apicad part of the fork. This is more marked on the fourth costa. The fifth is again simple; the sixth and seventh are bifurcatingly branched, the orad branch of the sixth being slightly the stronger, but in the seventh both branches are equal in strength. The eighth costa is bifurcatingly forked but the greater strength is in the apicad branch. The ninth costa has the character of a simple rib with an orad branch separated from it dorsally, this having the appearance of a free intercalated rib. Then follows the *a* system. On the whole, then, in this intersphincterial region the stronger part of the branching costa is the apicad portion, the orad branch being mostly a little weaker and in one case still distinct from the apicad. In only one costa is the reverse the case. As already shown in the ontogeny of the holotype of *P. cubanensis*, the later whorls show a forward migration in the strength of the branches. Thus, practically all of the costæ of this intersphincterial series are in the condition shown by the first groups of later intersphincterial systems.

The *a* system which succeeds the group just described has the following arrangement: a_1 is strong, a_2 , which is weaker and not so salient as a_1 , branches off at 4.2 mm., above the line of involution, this point, therefore, being relatively as well as absolutely more ventrad than is the

point of branching in the preceding *a* system; a_3 separates off at 2.5 mm., above the line of involution and the strength of a_2 continues across the venter in a_3 ; a_4 appears as a free costa.

The next intersphincterial system, which begins at $4\frac{3}{4}$ volutions has the following arrangement. After the usual strong *o* costa follows a simple costa (I) with a pronounced orad deflection on the side of the whorl, a character which is found in the first costæ of all the succeeding intersphincterial groups, but has not up to this stage in the ontogeny been very marked. In group II on the right side the apicad branch is free, but on the left side it is still slightly in junction with the costa as a whole, the strength of which is continued in the orad branch. Group III on the right side has the greatest strength and continuity in the orad branch, but the apicad is still weakly joined to it, while on the left side the strength of both branches is about equal. These relations hold in the succeeding costæ with but slight variations. Thus, on the whole, the strengthening has passed to the orad branch, though this is not true for every costa as yet. The left side of the conch is a little more accelerated in this respect than the right.

At $5\frac{3}{4}$ volutions and on, the character is still essentially the same. The first costa of each group is simple, the other two branched (appearing bifurcated) with the strength more constantly in the forward branch, the apicad being frequently free.

VENTRAL GROOVE.—The last whorl of this species (Pl. XXXV, figs. 4c and 5) is of very great significance, since it provides the proof of the origin of the ventral groove seen in the internal molds of all of the Cuban species of *Perisphinctes* and noted as well in many European forms. This groove has been mistaken by some authors as identical with that present in the genus *Idoceras* and for this reason the rocks at Viñales were originally correlated with the Kimmeridgian of Mexico. The geologic significance of this apparently insignificant groove is, therefore, evident.

Because of the manner in which the individual whorls of *P. delatorii* separated during the process of preparation, I was able to see the dorsum and venter of several of them, and the last whorl fortunately retained on its dorsal surface the shell from the preceding whorl. By making a polished cross-section, shown in Pl. XXXV, fig. 5, I found that the shell is composed of two layers. The outer one, clearly formed by the edge of the mantle, showed a normal rounded venter with the costæ uninterrupted, the inner, however, was thickened at the middle and must have been subsequently formed by the mantle within the body chamber. This median

thickening produced a ridge which projected inward and which would give rise to a groove in the internal mold. Thus in *Idoceras* (Pl. XXXVI, fig. 3) the costæ in the shell appear bevelled down to the level of the median ventral line, while in the Cuban *Perisphinctes* they are perfectly continuous across the venter in the shell but in the internal mold there is a groove cut into the costæ. Morphologically the two smooth bands which are produced are totally unrelated, the one in *Idoceras* being formed at the aperture in the shell, the one in the *Perisphinctes* occurring only in the mold and being an expression in reverse of a secondary internal thickening of the shell. This median groove has been observed in a large number of European species of *Perisphinctes*, but all of these are known only from internal molds so that the significance of the groove and its mode of origin have never been determined. Pompeckj called attention to the fact that every specimen of *Perisphinctes plicatilis* which he had seen showed a groove and he regretted that none of them had any of the shell preserved. Some European authors have suggested that the groove was due to wear on the specimen but, since it is visible on the inner whorls when the specimen is broken down, such an explanation obviously is incorrect. The groove is neither of specific nor generic value as is the smooth band in *Idoceras*, for I have observed it in many genera of the *Stephanoceratidæ* as in *Dactylioceras*, *Stephanoceras*, *Gros-sourria*, *Ataxioceras*, and others. I have no explanation to offer for the reason of such a median thickening of the shell, but of the fact there can be no doubt.

SUTURES.—The preservation is of such a nature that no sutures are visible, except in the young whorls where they are not distinctive enough to be used for specific identifications.

HORIZON AND LOCALITY.—Lower beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Perisphinctes plicatiloides*, new species**

Plate XXXVI, Figures 1 and 2

1912. *Perisphinctes* aff. *orbigny* de Loriol. BURCKHARDT, Faunes Jurassiques et Cretaciques de San Pedro del Gallo, p. 22, Pl. IV, figs. 2-4.

Non

1818. *Ammonites plicatilis* Sowerby. SOWERBY, Min. Conch., p. 149, Pl. CLXVI.
 1842. *Ammonites plicatilis* Sowerby. D'ORBIGNY, Pal. Française, Terr. Jurassiques, p. 509, Pl. CXCII.
 1875. *Perisphinctes plicatilis* (Sowerby). AMMON, Die Jura-Ablagerungen zwischen Regensburg und Passau, p. 175.
 1875. *Perisphinctes plicatilis* (Sowerby). WAAGEN, Jurassic Cephalopoda of Kutch, p. 189, Pl. LI, figs. 2a, b, 3; Pl. LII, fig. 3.

1898. *Perisphinctes plicatilis* (Sowerby) Philipps. SIEMIRADZKI, Monographische Beschreibung der Ammonitengattung *Perisphinctes*, p. 249, Pl. xxv, fig. 45.
1898. *Perisphinctes plicatilis* (Sowerby) D'Orbigny. SIEMIRADZKI, *loc. cit.*, p. 251.
1898. *Perisphinctes plicatilis* (Sowerby) D'Orbigny. DE RIAZ, Ammonites de Trept, p. 9, Pl. I, and Pl. III, figs. 1, 2, and 3.
1903. *Perisphinctes orbignyi* de Loriol. DE LORIOI, Jura Lédonien, p. 81, Pl. xi, fig. 2.
1904. *Perisphinctes plicatilis* (Sowerby). HEALEY, Upper Jurassic Ammonites, Q. J. G. S., LX, p. 55, Pl. ix, figs. 1, 2, text fig. 1.
1904. *Perisphinctes plicatilis* (Sowerby). HEALEY, Palæontologia Universalis, Pls. LVII, LVIII.
1907. *Perisphinctes healeyi* Neumann. NEUMANN, Die Oxford-fauna von Cetecho-witz, p. 29, Pl. II, fig. 5.

Among the *Perisphinctinæ* is a single, well-preserved internal mold (holotype, A. M. N. H. No. 18560) belonging to the *plicatilis* group. The specimen shows about five complete volutions, but practically none of the shell is preserved. During the process of fossilization the conch was filled with calcite crystals, the inner two-thirds of the internal mold consisting entirely of crystallized calcite, around which is a thin layer of chapapote. Finally, the main external part of the internal mold is a layer, about 2 mm. thick, composed of a mixture of chapapote and calcite. The interfacial angles of the calcite crystals often intersect the sutures, making it difficult to follow them.

The chief reasons for separating this species from the typical *plicatilis* as well as from other forms of that group, are that the sides of the whorls are convex instead of flat and the sutures are more complex and very distinct from those in other species of the *plicatilis* group in having a short ventral and long superior-lateral lobe.

SYNONYMY.—So many different forms have been referred to *plicatilis* of either Sowerby or D'Orbigny and such conflicting statements are found in the literature concerning the characters of the real *plicatilis*, that it seems advisable to set down a clear statement of the facts in order that we may, perhaps, arrive at a more definite conception of this very common species.

In 1818 Sowerby figured and described *Ammonites plicatilis* from a formation since identified as the Upper Corallian. The holotype was an internal mold from Buckland's Collection and is now in the University Museum at Oxford. The protolog and protograph are so poor that subsequent authors have, as a rule, considered them insufficient for the definition of the species, but recently the holotype has been redescribed and refigured so that we are sure of its characters (Healey, 1904a, p.

55, Pl. ix, figs. 1, 2, text fig. 1; 1904b, Pls. LVII, LVIIIa). It is a compressed form, with rounded venter but flat sides, the whorls in the adult being about as high as wide so that the cross-section is quadrangular with rounded corners. The involution is about one-fourth; constrictions are very faint; there are sixty-eight long costæ on the whorl ending at a diameter of 96 mm. and most of these branch on the venter, a few bifurcating and rarely some remaining single. Miss Healey has given a careful drawing of the suture in the *Palæontologia Universalis* (1904b, Pl. LVII, T. 1b) which shows that it was very complex and consisted of three lobes in which the first dorsal one is longer than the others, while the ventral and superior-lateral lobes are of about equal length.

D'Orbigny in the *Paleontologie Française* (1842, pp. 509-514) redescribed *A. plicatilis* Sowerby including in his synonymy a large number of species which subsequent authors have again separated out as wholly distinct. His description was a composite one including the characters of the many forms which he considered to be *plicatilis*, but the European consensus of opinion has settled upon the illustration which he gives on Pl. CXCII in figs. 1 and 2 as the true *plicatilis*, the one which is to be regarded as Sowerby's species.

This idea that D'Orbigny's figures represented the true *plicatilis* appears to have originated with Seebach. He visited England with the express purpose of studying in the field and the museum the formations and collections of the Jurassic that he might compare them with the northwest German Jura. In his volume on the Jura of Hanover, he makes the statement that, after seeing Sowerby's types of *plicatilis* in the British Museum, he is convinced that that author had in mind the same species which D'Orbigny described and illustrated so much better (Seebach, 1864, p. 156). But Sowerby's type of *plicatilis* is only a single specimen and it is in the University Museum at Oxford so that, whatever Seebach saw, and I doubt not it was the cotypes of *A. biplex* Sowerby, which are in the British Museum, it was not the holotype of *plicatilis*. However, be this as it may, Seebach's statement has been widely accepted and many authors at present use the designation *P. plicatilis* (Sowerby) D'Orbigny or omit all reference to Sowerby.

Siemiradzki, on the other hand, fell into a different error. For some reason which is not made clear, he states (1898-1899, pp. 70, 249-252) that Sowerby's type of *plicatilis* is lost and that, the original description and figure being poor, we must rely upon the next reference in the English literature and he refers to Phillips' figure in the 'Geology of Yorkshire' (1829, Pl. iv, fig. 29). As Miss Healey has pointed out (1904a, p. 54),

this was a wrong reference, since the species illustrated is a keeled form called *Ammonites solaris* by Phillips, and Siemiradzki must have been referring to the third edition of the 'Geology of Yorkshire' (1874) in which Pl. IV, fig. 29 shows a form which is called *Ammonites solaris* (erased 1874) and receives the new designation *A. plicatilis* (replacing *A. solaris*) (1874, p. 325) but correctly referred to on p. 265 as *A. plicatilis* Sowerby where reference is given to Sowerby's Pl. 166. In the second edition of the 'Geology of Yorkshire' (1835) the illustrations are the same as in the first. Because of this error, Siemiradzki places Sowerby's species in the Ornatenton or Middle Kellaway instead of in the Upper Corallian where it belongs.

There can, however, be no doubt that Sowerby and D'Orbigny had two distinct forms in mind and since both have been described and figured with sufficient precision for later recognition, and particularly since there is no longer any doubt about Sowerby's holotype, by the laws of priority the name *plicatilis* must be used for forms fitting Sowerby's description, and a new name must be given to the species called *plicatilis* by D'Orbigny. The first to recognize this necessity was de Loriol (1903, p. 82) who gave the name *P. orbignii* to D'Orbigny's *Ammonites plicatilis*, a species characteristic of the zone of *Peltoceras transversarium* of the Oxfordian.

Neumann has introduced a new confusion into the synonymy by giving to D'Orbigny's *plicatilis* the name of *P. healeyi* (1907, p. 29), ignorant of the fact that in 1903 de Loriol had already, as we have seen, called it *P. orbignii*. The name *P. healeyi* would automatically, under these conditions, become dead and there would also be no reason for using Neumann's *Healeyi*-group for this and related species. But it is clear from his description and figures (1907, Pl. II, figs. 5a, b) that the species which he has found in the *Cordatus*-beds, is different in several important points from D'Orbigny's. It is a thicker, coarser form, with broader, more widely separated costæ which, instead of passing in a straight line from the umbilicus to the flanks of the whorls, are deflected apicad on the umbilical shoulder. The involution is greater, the cross-section of the whorls is different, and the constrictions are much deeper. Moreover, Neumann's species comes from the *Cordatus*-beds of the Lower Oxfordian, D'Orbigny's from the *Transversarius*-beds of the Upper Oxfordian. The name *healeyi*, therefore, might still stand if applied to the Cetechowitz species, but Neumann's synonymy could not be accepted, particularly since he has included in it both the original *plicatilis* of Sowerby identified by later authors and species referable to D'Orbigny's *plicatilis*.

I have before me two specimens from Germany, the one (No. 1813/3, A. M. N. H. Coll.) being just a little smaller than Sowerby's holotype, the other (No. 9822 G, Palæontological Museum, Columbia University) a little smaller than D'Orbigny's *plicatilis*. The former comes from Württemberg, the latter from Haldem, Hanover, and, while not from the typical localities, they yet show very clearly how different are the forms described by the two authors. The one which I have identified as *P. plicatilis* (Sowerby) has the same dimensions as the holotype and is to be distinguished from the Hanover specimen by being on the whole much thicker and more massive, with deeper umbilicus and more pronounced umbilical shoulder, while the costæ, which are straight, in D'Orbigny's, showing no deflection on flanks or venter, are in Sowerby's species slightly deflected apicad on the umbilical shoulder and on the venter they bend orad, as well as being throughout less sharply defined. Once the two forms have been seen side by side there is no mistaking them, however large the specimen may be, for there are fundamental differences in form, involution, costal development, and sutures that separate them from the very beginning of their ontogeny and they do not converge in later stages.

We must thus recognize three distinct species in the *plicatilis* group, no two of which can be united.

Perisphinctes plicatilis (Sowerby), 1818. Upper Corallian—*Plicatilis* beds. Protograph: Sowerby, Min. Conch., p. 149, Pl. CLVI.

P. orbignyi de Loriol, 1903. Upper Oxfordian—*Transversarium* beds. Protograph: de Loriol, Jura Lédonien, part 2, p. 81, Pl. xi, fig. 2.

P. healeyi Neumann, 1907. Upper Kellaway—*Cordatus* beds. Protograph: Neumann, Die Oxfordfauna von Cetechowitz, p. 29, Pl. II, figs. 5a, 5b.

De RIAZ has described and figured from the *Transversarium* beds of Trept a large series of specimens of the *plicatilis* group. He has designated them *P. plicatilis* Sowerby D'Orbigny (De Riaz, 1898, pp. 9-12, Pls. I-III, figs. 1, 2, 3,); if the identification is correct, the forms should be called *P. orbignyi* de Loriol, but the specimen which he considers as the typical *plicatilis* (1898, Pl. III, figs. 1a, b) is thicker throughout and slightly more involute than D'Orbigny's. Therefore it is not unlikely that the Trept species are variations from D'Orbigny's type, and should at least receive a variety name. This fauna of Trept is particularly interesting as providing both young and mature individuals, the *Perisphinctes* attaining to an unusual size. Thus de Riaz mentions one *plicatilis* 236 mm. in diameter. However, it is apparent that there are manifold difficulties in comparing such large individuals with D'Orbigny's holotype which was recognized to be a young form and measured only 85

mm. in diameter. Among the specimens in the *plicatilis* group, de Riaz has found a number which differ in one or more characters or in proportions from D'Orbigny's type, and these he has classed together simply as *P. aff. plicatilis* d'Orb., not finding enough marked differences to found new species. Undoubtedly this group of forms which are not strictly true to type could be arranged in a number of evolutionary lines which were derived from some generalized and fundamental form by allometric or rectigradational changes or by both.

Waagen has recorded *P. plicatilis* Sowerby from the Kuntkote sandstone of Kutch in the zone of *Peltoceras transversarium* (1875, p. 189, Pl. LI, figs. 2a, b, 3; Pl. LII, fig. 3), but the specimens are like neither Sowerby's nor D'Orbigny's species, differing from both in the disposition and form of costæ and in not showing the characteristic lateral compression.

FORM AND PROPORTIONS.—The conch of the holotype of *Perisphinctes plicatiloides* is only slightly involute and, in consequence, the umbilicus is broad. The venter is uniformly rounded, passing into the gently convex sides without any indication of ventro-lateral shoulders. The sides pass more abruptly, but still with a rounded contour, to the line of involution, producing a rather indefinite umbilical shoulder and a comparatively shallow umbilicus. The latter becomes proportionally broader with age as shown in column 12 of Table 5. Where the conch is approximately 35 mm. in diameter, the height and width of the whorls

TABLE 5. Allometric Changes in *Perisphinctes plicatiloides*, new species

<i>d</i> mm.	<i>h.i.</i> mm.	<i>h.i.</i> <i>d</i>	<i>h.i.z.</i> mm.	<i>h.i.</i> — <i>h.i.z.</i> mm.	<i>h.i.z.</i> <i>d</i>	<i>h.p.</i> mm.	<i>w.</i> mm.	<i>w</i> <i>d</i>	<i>w</i> <i>h.i.</i>	<i>u</i> mm.	<i>u</i> <i>d</i>	<i>h.i.</i> <i>u</i>
1	2	3	4	5	6	7	8	9	10	11	12	13
35.0 (approx.)	11.5	.....	.....	.....	.....	14.9	11.7	.....	1.01	.....	.....	.....
45.6	14.3	0.31	.....	.....	.....	19.8	13.9	0.30	0.97	21.0	0.46	0.68
51.2	15.4	0.30	.....	.....	.....	22.3	15.1	0.29	0.98	23.9	0.46	0.64
57.2	17.3	0.32	14.9	2.4	0.26	24.0	16.4	0.28	0.94	28.1	0.49	0.61
62.8	18.0	0.28	15.4	2.6	0.24	27.2	17.2 (estim.)	0.27	0.95	30.8	0.49	0.58

are about equal, but beyond this the height becomes steadily greater than the width, though, because of the convexity of the sides, the cross-section at no time appears either squarish or trapezoidal as in the typical *plicatilis*. The ratio of height of whorl to width of umbilicus becomes progressively less as does also the ratio of height of whorl to the diameter (columns 3 and 13 of the table), two changes which indicate that the amount of involution decreases with age.

COSTÆ AND SPHINCTERS.—The earliest volution of the conch appears to be smooth with strongly convex sides. As in the other *Perisphinctes* of this fauna, the first pronounced surface character to appear is a constriction which antedates the costæ. The first of these is seen just beyond one and a quarter volutions, arising apparently on the umbilical shoulder in the internal mold. These early costæ show no evidence of branching, although this might take place on the ventral portion which is, of course, invisible on account of the involution. There are about six costæ preceding the next constriction.

At about one and a half volutions the first branching in the *a* system occurs, the a_1 costa being very strong while its branch is less pronounced both in height and sharpness. The actual divergence of a_2 is near the middle of the flanks, but a_1 is very strong and thick below this point, suggesting that dorsally the two are confluent.

Beginning with the constriction which marks the end of the second volution, the costal arrangement in the five succeeding intersphincterial areas has certain unusual features which are most suggestive as to the origin of "bifurcations." At the beginning of the third volution two simple costæ follow the *o* costa and are essentially parallel to it, showing only a slight divergence ventrally such as is normal for simple, unbranched costæ. The third costa, however, bends towards the second above the umbilical shoulder, almost but not quite touching it. (See Fig. 1, p. 647.) The space between the ventral ends of the third and fourth costæ is so small as to suggest that the former remains simple on the venter, but the space between the fourth and fifth, and fifth and sixth costæ, etc., is wider, suggesting the presence of a ventral branch in each one of these. After the next constriction, the first costa is still simple, parallel, and close to *o*, but the dorsal ends of the second and third costæ are united, their ventral portions forming two branches of equal strength, while the costæ oral of this have the position and divergence indicative of ventral branching. Thus, counting the costæ on the umbilical shoulder, we would say that the second costa is branched or "bifurcates." The next succeeding intersphincterial group shows this

same tendency carried still further. Again, if we count the costæ on the umbilical shoulder, the second one shows its point of "bifurcation" moved ventrally until it is about 3.5 mm. above the line of involution, but it is still considerably below the line of inclusion. The first costa, which was simple in the preceding intersphincterial system, is now branched, the divergence occurring at about 2.7 mm. above the line of involution. It thus appears that, after branching is established, the point of divergence of the branch moves progressively ventrad until it reaches such a position that it is covered by the next succeeding whorl. At the same time, the branching habit of the costæ is pushed backward in each system until all the costæ branch.

In the intersphincterial system following the one just described, all of the points of divergence have moved so far ventrally as to be covered by the succeeding volution, as is indicated by the mode of divergence of the costæ. Thus, the lateral costæ appear to be simple, but in reality they are the compound stems of branched individuals. That such is indeed the case is clearly shown where the venter of the conch is first exposed and where all of the lateral costæ divide into two branches, which, however, are entirely concealed when the succeeding whorl (which separated off during the preparation of the specimen) is placed in position.

Where the ventral portion of the final whorl preserved is first exposed, it is seen that the branching is still bifurcate, but, as in *P. cubanensis*, the strength of the costa passes progressively forward and as this takes place the apical one of the two branches becomes free first on one and then on the other side of the whorl after the manner described for *P. cubanensis*. A third branch on the oral side of a costa occasionally is seen, forming a trifurcation, but the trifurcating type of costæ is more characteristic of the last part of the final whorl where, however, bifurcation still persists in some cases.

The whorl ending at a diameter of 62.8 mm. has 42 lateral and about 84 ventral costæ, which, when the simple *o* costæ are subtracted, leaves most of the costæ bifurcating and only a few trifurcating. Wherever the shell is preserved, the costæ are seen to arise nearly but not quite at the line of involution, leaving a very narrow smooth band which appears wider on the internal mold because the costæ seem to arise more nearly on the umbilical shoulder. The costæ are strongest on the flanks, where at times they are quite salient, particularly in the younger whorls. Towards the end of the last whorl they become more rounded and less elevated. Throughout the entire conch the costæ show a slight

curvature on the flanks and a faint backward deflection on the umbilical shoulder, but this is much less pronounced than in *P. cubanensis*. On the venter the costæ are uniformly weaker, and there is a marked median faintness giving rise to the appearance of a median depression on the venter of the internal mold. As in the case of *P. cubanensis*, this is due to a median ventral thickening of the shell on the interior. Unfortunately, there is no place in this specimen where the shell is preserved on the venter itself, so that the exterior ventral aspect of the shell is not determinable for this species, but it is very probable that no depression or interruption of the costæ is shown on the venter of the shell proper any more than it is in *P. cubanensis* and other forms where the shell is preserved. Of the internal thickening there can be no doubt, for it can be seen on one fragment of the last volution where the shell of the preceding whorl is preserved on the impressed zone.

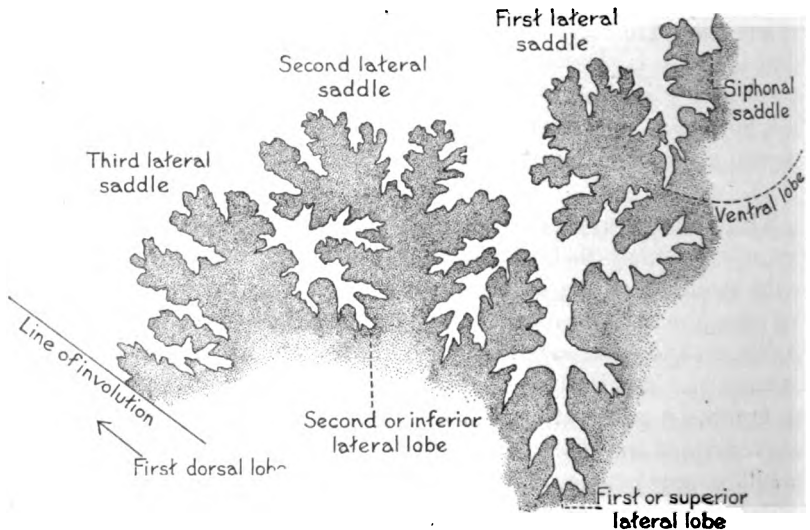


Fig. 8. Suture line of *Perisphinctes plicatilloides*, new species.

SUTURES.—The suture (Fig. 8) is more complex than in any other species of the *plicatilis* group. The ventral lobe is about twice as long as wide and has two long terminal branches, each of which shows numerous minor indentations. These branches constitute the siphonal saddle, which is divided by a small median lobe. The first or superior-lateral lobe is long and narrow, terminating in three pointed prongs and showing three major additional lobes on either side with many smaller indenta-

tions. This lobe extends twice as far apicad as either the ventral or second lateral lobe and is longer even than the first dorsal lobe. The second or inferior-lateral lobe is notably shorter than the first and is directed obliquely toward it. The first lateral saddle does not extend quite so far orad as the siphonal saddle, is unsymmetrically divided by many minor inflections, and is smaller than the other two lateral saddles. The second lateral saddle is long, unsymmetrical, broader than the superior lateral lobe and terminates about on a line with the siphonal saddle. The third lateral saddle is a little shorter than the first lateral saddle and is rather evenly indented on its dorsal side by the inflections of the first dorsal lobe.

The suture of *Perisphinctes plicatiloides* thus differs markedly from that of *P. plicatilis* (Sowerby) in having the first lateral lobe so much more prominent than the other lobes. In the English species the first dorsal lobe is longer than the others, while in D'Orbigny's *plicatilis* it is the ventral lobe which has the greatest length and this is the case in de Loriol's *P. orbignyii* from the Jura and Waagen's *P. plicatilis* (Sowerby) from India. Unfortunately Burckhardt was unable to prepare the sutures of the Mexican *P. aff. orbignyi* de Loriol which, from its other characteristics, appears to be the same as *P. plicatiloides*, although identity of ammonites can never be established on form alone and without the corroborative evidence of the sutures.

On account of the great dissimilarity in the fundamental suture pattern in the various European forms which are called *plicatilis* and because all differ in this respect from the Cuban species, it seems probable that the "*plicatilis* group" is made up more largely of homœomorphic equivalents than of genetically related species. All of the *plicatilis*-like ammonites show certain similarities in form and proportions and in the arrangement of costæ, but it is well known that these characteristics are not so reliable as the sutures in determining genetic relationships and, since the sutures are so markedly different in the various species, there seems to be little justification for the grouping of these unrelated forms into a *plicatilis* series unless we do so merely for convenience in speaking of the numerous species throughout the world which have certain external features in common.

RELATED FORMS.—As is the case with the other Cuban species, this finds its nearest relative in the Mexican fauna. Burckhardt has described and figured a specimen identified as *Perisphinctes aff. orbignyi* de Loriol (1912, p. 22, Pl. IV, figs. 2-4). No European *plicatilis* is so like the Cuban one in form, evolution and proportions as is this Mexican form, yet there

are certain slight differences, the most noticeable of which is in the costæ. In Burckhardt's species these are salient and are strongly curved on the umbilical shoulder, resembling, in this respect, the specimens described by DeRiaz from Trept. Both the Cuban and Mexican forms differ from D'Orbigny's in having convex instead of flat, compressed sides, the cross-section of the first two being almost identical but unlike that of the third. Burckhardt has called attention to the fact that the costæ on his specimen, which is an internal mold, are enfeebled on the median ventral line, in which respect it differs from D'Orbigny's *plicatilis*. This difference, I think, is only apparent, for Pompeckj, as we have seen, has stated that all of the northwest German *plicatilis* show the depression in the internal mold. All of the illustrations given by European authors in recent works show that a depression is present, and I doubt not but that D'Orbigny either omitted reference to this feature or else that he figured a specimen in which the shell was preserved and in which, consequently, the median furrow would not be seen.

HORIZON AND LOCALITY.—Lower zone of Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Perisphinctes* cf. *alterniplicatus* Waagen**

1875. *Perisphinctes alterniplicatus* WAAGEN, Jurassic Fauna of Kutch, Palaeontologia Indica (9), I, p. 199, Pl. I, figs. 2a, b.

1912. *P. cf. alterniplicatus* WAAGEN. BURCKHARDT, Faunes Jurassiques et Cretaciques de San Pedro del Gallo, p. 34, Pl. VII, figs. 1-3.

There is a single specimen (A. M. N. H. No. 18576) showing a quarter sector through six whorls and I have referred it provisionally to *P. cf. alterniplicatus*. Since I cannot measure the diameter, it is impossible to give any of the shell ratios, and the preservation is such that no sutures are visible, so that the identification must be made on the form of the whorls and the character of the costæ. The distinctive feature about the costæ is that a long costa on one side of the whorl, when traced across the venter, ends in a short costa instead of being continued in a long one, this arrangement producing an alternation on the two sides of the whorl which suggested the specific name *alterniplicatus*.

HORIZON AND LOCALITY.—Lower beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

OCHETOCERAS Haug***Ochetoceras canaliculatum*** (von Buch) **burckhardti**, new variety

Plate XXXVII, Figures 1, 2, and 3

1912. *Ochetoceras canaliculatum* (d'Orbigny) von Buch. BURCKHARDT, *Faunes Jurassiques et Cretaciques de San Pedro del Gallo*, p. 5, Pl. I, figs. 1-7.

SYNONYMY.—The specific name *canaliculatus* was first used in print by von Buch in 1831 for a number of small ammonites from the Coral Rag of Woschnau on the Eck near Aarau in the Swiss Jura (1831, Pl. I, figs. 6, 7, 8). He identified his specimens as *Ammonites canaliculatus* Münster, describing them as small, with many costæ which are ordinarily divided a little above the lateral canal; in a specimen 5 cm. in diameter he counted 48 to 52 costæ near the venter which he stated to be sharp and very finely crenulated. Oppel, who had von Buch's holotype before him as well as several specimens labelled by Münster, states that von Buch's description was not in accord with the original specimen, for the latter showed no bifurcation of the costæ, a feature which was expressly noted and figured by von Buch. The material in Münster's collection was unlabelled, while the specimens in the Bayreuth Museum described by him in 1833 as *A. canaliculatus* belonged to a number of distinct species from different horizons (Oppel, *Jurassische Cephalopoden*, 1862, p. 157). Oppel considered that the figures given by D'Orbigny were more accurate than the protograph and since he had the holotype in his possession and refigured it (*loc. cit.*, Pl. LI, fig. 3) we may accept his judgment in the matter.

D'Orbigny identified an ammonite common in the French Oxfordian as *A. canaliculatus* and ascribed the species to Münster (Terr. Juras., Pl. cxcix, figs. 1, 2). It would seem that D'Orbigny described and figured a form identical with von Buch's holotype, though not agreeing with that author's protolog or protograph which Oppel states are incorrect. If we accept Oppel's redescription and re-illustration of von Buch's holotype, then the species name should be credited to the latter author. At any rate, by no rule of priority could the name *canaliculatus* be ascribed to D'Orbigny, for if this form is the same as von Buch's his identification would simply be listed in the synonymy of *canaliculatus*, and if it is not the same a new name would have to be given to it, since both species belong to the same genus, *Ochetoceras*, and the name *canaliculatus* must be retained for von Buch's holotype since that has now been redescribed by Oppel. Haug, who placed this species in his genus *Ochetoceras*, has also given the priority to von Buch without, however, stating his reasons (1885, p. 697). According to this line of reasoning, Burckhardt should not have identified the Mexican species as *O. canaliculatum*.

(D'Orbigny). For reasons which will be brought out as I describe the Cuban species, I consider it to be identical with the Mexican species and regard both as a variety of the European *canaliculatum*.

The following is a synonymy of the critical references to *Ochetoceras canaliculatum* (von Buch):

1831. *Ammonites canaliculatus* VON BUCH, Recueil de Planches de Petrifications Remarquables, Pl. I, figs. 6, 7, 8.
 1842. *Ammonites canaliculatus* Münster. D'ORBIGNY, Paléontologie Française, Terr. Jurassiques, p. 525, Pl. CXCIX, figs. 1, 2 and 6, non 3.
 1862. *Ammonites canaliculatus* von Buch. OPPEL, Ueber jurassische Cephalopoden, Pal. Mitth., III, p. 157, Pl. LI, fig. 3.
 1885. *Ochetoceras canaliculatum* (von Buch). HAUG, Monographie der Ammoniten-gattung Harpoceras, p. 697.

FORM AND PROPORTIONS.—There is a single well-preserved representative of this species (holotype, A. M. N. H. No. 18561) showing practically all of the shell intact which is unusual in this material. The specimen, judging from its comparatively small size and the fact that there are only about two and a half volutions present, is probably only a sub-mature individual, so that the characters and proportions which it shows are not to be considered wholly diagnostic for the species but only for the stage of development represented.

The conch is compressed and discoidal. The whorls increase rapidly so that involution is almost complete, giving, with increased diameter, a proportionally smaller and smaller umbilicus. In cross-section the whorls are about two and a half times as high as broad, the ratio decreasing with the age of the conch, as may be seen from the Table 6 (columns 2, 8, 10).

TABLE 6. Allometric Changes in *Ochetoceras canaliculatum* (von Buch) *burekhardtii*, new variety

<i>d</i> mm.	<i>h.i.</i> mm.	<i>h.i.</i> <i>d</i>	<i>h.i.z.</i> mm.	<i>h.i.—</i> <i>h.i.z.</i> mm.	<i>h.i.z.</i> <i>d</i>	<i>h.p.</i> mm.	<i>w.</i> mm.	<i>w</i> <i>d</i>	<i>w</i> <i>h.i.</i>	<i>u</i> mm.	<i>u</i> <i>d</i>	<i>h.i.</i> <i>u</i>
1	2	3	4	5	6	7	8	9	10	11	12	13
.....	16.0	.....	.....	.....	.....	.....	8.6	.....	0.53	.....	.....	.....
.....	18.6	.....	.....	.....	.....	.....	8.8	.....	0.46	.....	.....	.....
38.4	22.0	0.62	.....	.....	.....	.....	9.8	0.26	0.45	5.7	0.14	3.86
52.5	28.2	0.53	.....	.....	.....	30.6	12.5	0.24	0.44	6.9	0.13	4.08
55.8	31.5	0.56	23.7	7.8	0.42	32.3	13.4	0.23	0.42	7.5	0.13	4.13

In shell proportions the Cuban form approaches so closely to the specimens described by Burckhardt from the upper beds of the Upper Oxfordian of Cerro del Volcan, Mexico, that there is no doubt that all belong to the same species, but each shows a greater or less degree of acceleration over D'Orbigny's holotype, not only in proportions but in all other characters, for which reason I have given the Cuban form a distinct varietal name and have included here Burckhardt's specimens for reasons more fully given below. A comparison of the more important shell ratios will bring out the relations existing between the European, Mexican, and Cuban species (Table 7).

TABLE 7. Comparison in Allometric Ratios of Species of *Ochetoceras*

	$\frac{d}{mm.}$	$\frac{h.i.}{mm.}$	$\frac{h.i.}{d}$	$\frac{w}{mm.}$	$\frac{w}{d}$	$\frac{w}{h.i.}$	$\frac{u}{mm.}$	$\frac{u}{d}$
<i>Ammonites canaliculatum</i> D'Orbigny (holotype) (European).....	94.0	52.64	0.56	22.56	0.24	0.43	12.22	0.13
<i>Ochetoceras canaliculatum</i> {1st spec. (D'Orbigny) (Mexican) {2d spec.	55.5 32.0	31.00 18.50	0.56 0.57	16.00 8.00	0.29 0.25	0.51 0.43	8.00 5.00	0.14 0.16
<i>O. canaliculatum</i> (von Buch) var. <i>burckhardtii</i> (holotype) (Cuban)	55.8	31.50	0.56	13.40	0.23	0.42	7.50	0.13

From these figures it is clear that the Mexican specimen having a diameter of 32 mm. has a cross-section of about the same proportions as those of the Cuban specimen 55.8 mm. in diameter, while that which is 55.5 mm. in diameter has the cross-section which is shown in the Cuban specimen at the place where it is only about 28 mm. in diameter. Thus the smaller of Burckhardt's specimens is more accelerated, the larger less accelerated than the Cuban form in respect to the ratio of thickness to height of whorl, while all three are more accelerated than D'Orbigny's holotype, for the Cuban specimen although only 55.8 mm. in diameter has almost the identical proportions as those in D'Orbigny's which is 94 mm. in diameter, and both of Burckhardt's specimens, though representing young individuals, are identical with, or closely approach, the proportions of the adult described by D'Orbigny.

The conch is strongly compressed, with the region of greatest thickness at about the middle of the whorl when that is 16 mm. high but changing position gradually in a dorsal direction. Where the whorl is 31.5 mm. high the maximum transverse diameter is 5.7 mm. above the umbilical shoulder, that is, at about one-fifth of the way from the umbilicus to the venter.

Dorsally the whorls end abruptly at the umbilicus where they bend down at a right angle. Where the whorl is 31.5 mm. high from umbilical suture to venter the transverse diameter at the umbilicus is 4.5 mm. On account of the close involution of the whorls, due in its turn to the very rapid increase in size, little of the early whorls is visible in the umbilical opening. Where the diameter is 55.8 mm. only 1.5 mm. of the preceding whorl is visible in the umbilicus.

One of the most striking features of the conch is a distinct lateral groove visible throughout the shell in the specimen being described. It becomes obsolescent in the last part of the final whorl which is preserved and, since the specimen is probably only a little more than half the size of the adult, it is to be expected that an ephebic conch would be entirely devoid of a definite channel although the growth-lines might well continue to bend forward in the position marked by the groove in earlier whorls. A constant centrodorsan position on the whorl is retained by the groove, the median line of which is 5.5 mm. from the umbilical shoulder when the whorl is 12.8 mm. high and 12 mm. from the umbilical shoulder when the whorl is 28 mm. high, the ratio in both cases being 0.43, showing the position of the groove to be at slightly over two-fifths of the distance from the umbilical shoulder to the venter. The groove at the beginning of the final whorl of our specimen is 0.5 mm. broad, widening to 1.5 mm. just before it loses its distinctness as a definite canal.

Where the actual shell is preserved, fine, closely crowded, radiating growth-lines are visible (Pl. XXXVII, fig. 3). On the inner flank, that is, between the umbilicus and the groove, these lines have a gentle uniform curvature forward passing from the umbilical shoulder, where they are fairly strong, towards the lateral groove. There they bend forward strongly, forming distinct lappets, which become less pronouncedly elongate as the groove becomes fainter, though still retaining a strong forward bend. On the specimen which I have it is impossible to trace the growth-lines across the groove where this is deep, but forward as it becomes obsolescent the lines may easily be followed from dorsum to venter. In the region where the groove is most pronounced the growth-lines on the outer flank, that is, between groove and venter, are moderately falsiform, the convexity forward being more pronounced than on the inner flank. Just before they reach the venter, the growth-lines become stronger and lose their convexity so that they run in a direction at right angles to the keel. There is thus produced an extremely fine carination or denticulation on either side of the keel. These two lines of ventrolateral carinations or angulations are strongly developed only in the largest part of the whorl.

KEEL.—Rising up between the two angulations is a pronounced and characteristic keel with smooth flanks which converge into the finely noded central ridge of the keel (Pl. XXXVII, fig. 2). The nodes are minute, but very distinct, there being five in the space of 22 mm. where the whorl is 28.2 mm. high. The keel here rises 1.5 mm. above the ventro-lateral angulations but in the young part of the shell it is much less prominent. While the cross-section of the keel in the largest part of the conch preserved shows a decided angle between the flanks and the flat groove on either side of the keel, this is wholly absent at the beginning of this same whorl, the flanks passing convexly up to the groove at the base of the keel. Thus in the older shell there are two angles, which in the younger shell are represented by a convex and a concave curve, respectively.

The siphuncle is visible at a number of places on the specimen and measures 1 mm., in diameter at the maximum (Pl. XXXVII, fig. 2). The outer edge of the siphuncle rises above the ventro-lateral angulations, as may be seen in places where the median keel is broken away.

COSTÆ.—Paralleling the growth-lines are a few rather widely separated folds or costæ which are more strongly developed on the inner than on the outer flanks. These costæ appear for only a short time in the ontogeny and characterize less than one complete volution. D'Orbigny noted that his specimen was smooth (except for the lateral groove) until it attained a diameter of 30 mm. when costæ appeared and continued until a diameter of 60 mm. was reached when the costæ disappeared. I have counted with certainty ten costæ on the inner flanks of the final whorl, but while they are more numerous on the outer flank I have been unable to count them because of the poor preservation of the shell. It is clear, then, that not only in shell proportions is the Cuban specimen more accelerated than D'Orbigny's and von Buch's holotypes, but also in the time of appearance and disappearance of the costæ in the ontogeny as well as the period of their duration. The costæ in their curvature, arrangement and ontogenetic duration are practically identical with those in the Mexican forms described by Burekhardt.

SUTURES.—At a diameter of 52 mm., the suture shows a ventral, two lateral, and two auxiliary lobes (Pl. XXXVII, fig. 3.) The portion of the ventral lobelying in the mesal plane is undecipherable on account of the preservation; the lateral branches are well developed and lie at right angles to the keel. The first or superior-lateral lobe is slightly longer than the ventral lobe and is divided into three main branches, the middle of which has a trifurcate termination, while the two lateral ones are

bifurcate. The second or inferior-lateral lobe occupies the lateral groove, is simple, and not so deep as the first lateral lobe. The first auxiliary lobe is trifid, the second is an almost unmodified lobe with slight indentations foreshadowing a tripartite division. The first or superior-lateral saddle is divided into two unequal parts by a lobe directed dorsally, the inner portion being larger than the outer and being again subdivided by a small lobe into two branches which have trifurcate terminations. The second lateral saddle is slightly larger than the first and also bipartite. The first and second auxiliary saddles have a few simple secondary lobes but a bipartite division is not marked. The saddles are broader than the corresponding lobes but of about the same length.

COMPARISON WITH RELATED FORMS.—This species in all of its characteristics is so similar to Burckhardt's *Ochetoceras canaliculatum* (D'Orbigny) from the Upper Oxfordian of Cerro del Volcán, Mexico, that I do not hesitate to say that the two are identical, differing from each other by only so much differential acceleration in certain characters as any two individuals of the same species living side by side may do. The Cuban form has the same general suture pattern as the Mexican form but it is not so complicated, and the lobes are relatively broader and the entire suture shows fewer secondary inflections. Thus, in respect to the suture, the Mexican form is more accelerated than the Cuban, but in certain shell proportions it is less accelerated, while the costæ are practically identical in the two. D'Orbigny's and Burckhardt's species have almost identical sutures, so that the remarks which were made in the comparison of the Mexican with the Cuban species hold in comparing the French with the latter. The species described by D'Orbigny is the common wide-spread Oxfordian form which occurs throughout Europe in the zone of *Peltoceras transversarium*, and the Mexican and Cuban species are simply geographical variants. I regard this species as the best and most reliable horizon-marker in the Cuban fauna.

HORIZON AND LOCALITY.—Upper zone of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

***Ochetoceras mexicanum* Burckhardt**

Plate XXXVIII, Figures 1, 2, and 3

1912. *Ochetoceras mexicanum* BURCKHARDT, Faunes Jurassiques et Cretaciques de de San Pedro del Gallo, p. 7, Pl. I, figs. 8-12.

DESCRIPTION OF THE CUBAN PLESIOTYPE

The only specimen (A. M. N. H. No. 18562) of this species so far collected from Viñales is a sub-mature individual showing two complete volutions and probably having one or one and a half volutions concealed

in the inner umbilical region. Thus the characters noted will not be those of the adult form and can be used only in identifying shells of about the same size. The specimen is well preserved, showing portions of the shell and in several places the entire keel remains intact.

FORM AND PROPORTIONS.—The conch is compressed, elliptical and closely coiled. On account of the pronounced involution the umbilicus is small and, the flanks of the whorls bending downward abruptly at the umbilical shoulder, the opening is surrounded by nearly vertical walls. Since only the last whorl is exposed enough to allow of measure-

TABLE 8. Allometric Changes in *Ocheloceras mexicanum* Burckhardt

d mm.	$h.i.$ mm.	$\frac{h.i.}{d}$	$h.p.$ mm.	w mm.	$\frac{w}{d}$	$\frac{w}{h.i.}$	u mm.	$\frac{u}{d}$	$\frac{h.i.}{u}$
1	2	3	4	5	6	7	8	9	10
35.0	19.4	.55	.....	11.8	.33	.60	5.3	.15	3.6
39.3	21.8	.55	.....	12.3	.31	.56	6.1	.15	3.5
41.0	23.2	.56	.....	12.7	.31	.55	6.6	.16	3.5
43.1	24.3	.56	.....	13.8	.32	.56	6.3	.14	3.8
44.7	24.8	.55	26.7	14.0	.31	.56	5.5	.12	4.7

ments being taken, it is impossible to make any important generalization about the trend of the various allometric changes. The ratios of height to diameter and width to diameter remain about constant showing that the conch does not change much in general proportions. There is a marked increase in the amount of involution as brought out by the figures in columns 8, 9, and 10 in Table 8. The width of the umbilicus shows an absolute decrease which leads to a relative decrease in the ratio of that width to the diameter and an increase in the ratio of the height of the whorl to the width of the umbilicus.

LATERAL GROOVE.—At slightly less than half-way from the umbilicus to the venter, there is a rather pronounced lateral groove which becomes fainter and shallower towards the end of the specimen (Pl. XXXVIII, fig. 3). On the inner part of the flanks numerous regularly-spaced costæ are developed. They arise at the umbilical shoulder where they are faint and attain their greatest prominence at the edge of the lateral

groove. These costæ are directed obliquely orad across the sides and, at the beginning of the last whorl of the specimen, are strongly deflected orad at the lateral groove. The costæ die out in the groove and begin again on the outer flanks. In some cases it is evident from the continuity of the growth-lines that the costæ on the ventro-lateral side of the groove are continuations of those on the dorso-lateral, but there are also many additional intercalated ones. Thus, on the outer side of the groove there are 43 costæ and on the inner only 22. The costæ on the ventro-lateral area arise at the groove, are strongly deflected apicad, and then bend orad so that they have the form of a shallow sicle, concave toward the oral opening; as they approach the venter they attain their maximum height and breadth and are sharply deflected orad, the angles thus produced on the successive costæ forming a continuous abdominal angle between the ventral and lateral zones.

KEEL.—The costæ end at the abdominal angle above which rises the keel. On the sides this has fine, closely crowded crenulations which terminate in minute denticulations of which I counted nine in a distance of 5.4 mm. The keel rises to a maximum height of 1.6 mm. above the siphuncle, which is shown at a number of places on the specimen and which is 1.5 mm. in diameter (Pl. XXXVIII, fig. 2).

Where the shell has been preserved, the fine growth-lines are visible giving rise to striæ parallel to the costæ. The growth-lines can be most clearly seen in the lateral groove.

SUTURES.—The sutures are relatively simple, consisting of a ventral, two lateral, and two auxiliary lobes with the corresponding saddles. The ventral lobe has two rather long terminal branches which are directed obliquely apicad. The superior-lateral lobe is long and narrow with a central, trifid terminal branch, and simple secondary lobes. The second lateral lobe occupies the lateral groove, is unsymmetrical, and is shorter than the first lateral lobe. The two auxiliaries are progressively shorter and simpler. The superior lateral saddle cannot be studied on account of fractures in the specimen. The inferior lateral saddle is asymmetrical, being divided by a pointed secondary lobe into two parts, each of which is differently modified by added inflections. The three auxiliary saddles are decreasingly shorter and show a terminal division into two parts.

COMPARISON WITH RELATED FORMS.—This species is identical with the Mexican form described by Burckhardt. The Cuban specimen is smaller than the holotype, so that there is necessarily a slight difference in shell ratios but it is no greater than would be expected. The sutures

are somewhat simpler in the Cuban form but have the same pattern and same fundamental divisions. Burckhardt has pointed out that the Mexican form is closely related to the shell called "*Ammonites canaliculatus*" by Quenstedt (Ammoniten des schwäbischen Jura, Pl. XCII, figs. 1-5), which is characteristic of zone β of the White Jura or the zone of *Pelto-ceras bimmamatum*. I most decidedly agree with Burckhardt that Quenstedt's species cannot be united with *Ochetoceras canaliculatum* as de Loriol has done (Oxfordien superieure du Jura Lédonien, p. 24), for the former species is accelerated in the mode of development of the costæ and in the complexity of the sutures. The Cuban and Mexican *O. mexicanum* are clearly ancestral in all their characters to the "*A canaliculatus*" as described and figured by Quenstedt. This fact adds corroborative evidence as to the age of the beds containing *O. mexicanum*; it must be lower than the horizon of *Pelto-ceras bimmamatum* and this has been shown to be the case by the presence of *O. canaliculatum* in the same beds.

HORIZON AND LOCALITY.—Upper zone of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

ATAXIOCERAS Fontannes

Ataxioceras virgulatus (Quenstedt)

Plate XXXVIII, Figures 4 and 5

- 1858. *Ammonites virgulatus* QUENSTEDT, Der Jura, p. 593, Pl. LXXIV, fig. 4.
- 1888. *Ammonites virgulatus* QUENSTEDT, Die Ammoniten, III, p. 923, Pl. c, fig. 5.
- 1912. *Ataxioceras virgulatus* (Quenstedt). BURCKHARDT, Faunes Jurassiques et Cretaciques de San Pedro del Gallo, p. 35, Pl. VII, figs. 4-14.

DESCRIPTION OF THE CUBAN PLESIOTYPE

A single somewhat crushed specimen (A. M. N. H. No. 18563) of this species was found by Mr. Brown, and I have identified three representatives of the species among the material sent by Dr. Roig. The specimen which I have figured is a little over 60 mm. in diameter, being twice as large as any of the specimens found by Burckhardt at San Pedro del Gallo. It shows about four and a half complete volutions, the last quarter of the final one being crushed. More of the shell is preserved than is usual in this Cuban material, but in places the finer surface characters are obliterated by chapapote flakes and calcite.

The conch, in the beginning, is smooth, with very convex sides and rounded venter. At about one and three-eighths volutions the first costa appears as a short fold (1 mm. long) directed orad, arising on the umbilical shoulder and passing across the flanks for about a third the distance, that is, just to the line of inclusion. The first constriction comes

in at one and a half volutions and is followed by simple, unbranched costæ which have a strong orad trend. In the intersphincterial region beyond the second constriction the first branching of costæ is seen, occurring on the umbilical shoulder. These details of the early part of the conch are shown on one side of the specimen where a portion of the first half of the third volution has broken away. Beyond this the costæ are well shown, arising a little below the umbilical shoulder and passing across the flanks diagonally and without branching. The costæ are fine, sharp, and numerous, there being thirty-two on the last half of the third volution, counted on the umbilical shoulder. On the last whorl each costa branches once about midway across the flanks, the branches as a rule remaining united so that there are few intercalated costæ.

The constrictions are numerous and well defined, but neither broad nor deep. There are nine constrictions on the fourth whorl in a little over half a volution. They occur at irregular intervals and are directed diagonally orad across the flanks of the conch.

On account of the crushing of the specimen, I could not make the usual series of measurements but can give the figures at one diameter.

d	$= 44.8$ mm.	$\frac{h}{d}$	$= .44$
$h. i.$	$= 19.8$	$\frac{w}{d}$	$= .31$
w	$= 14.2$	$\frac{u}{d}$	$= .28$
u	$= 12.6$		

The ratios correspond fairly well with those for the largest specimen found by Burckhardt.

The conch as a whole is compressed, the whorls having almost flat flanks which bend down abruptly at the umbilical shoulder but which pass without any angulation into the evenly rounded venter. The umbilicus is broad, open and not deep, but yet clearly defined.

The sutures are not shown.

HORIZON AND LOCALITY.—Upper beds of the Upper Oxfordian; Viñales, Pinar del Rio, Cuba.

BIBLIOGRAPHY

- AMMON, LUDWIG. 1875. Die Jura-Ablagerungen zwischen Regensburg und Passau. Abhandlungen des zoologisch-mineralogischen Vereines in Regensburg. X, München, 200 pp., 4 plates.
- BUCH, LEOPOLD VON. 1831. Recueil de Planches de Pétrifications Remarquables. Berlin, 20 pp., 8 plates.
- BUKOWSKI, GEJKA. 1887. Ueber die Jurabildungen von Czenstochau in Polen. Beiträge zur Päl. Öst.-Ungarns und des Orients, V, pp. 71-171, 6 plates.
- BURCKHARDT, CARLOS. 1912. Faunes Jurassiques et Cretaciques de San Pedro del Gallo. Instituto Geologico de Mexico. Boletin Num. 29, 264 pp., 46 plates.
- CASTILLO, ANTONIO DEL AND AGUILERA, JOSE G. 1895. Fauna Fossil de la Sierra de Catorce San Luis Potosi. Boletin de la Comision Geológica de México.
- CHOFFAT, PAUL. 1893. Description de la Fauna Jurassique du Portugal. Classe des Céphalopodes. Première série: Ammonites du Lusitanien de la Contrée de Torres-Vedras, Lisbonne, 82 pages, 20 plates.
- DE LA TORRE, CARLOS. 1909. Excursion Cientifica a Viñales. Anales de la Academia de Ciencias Médicas, Fisicas y Naturales de la Habana, XLVI, pp. 99-103.
1910. Comprobation de l'existence d'un horizon jurassique dans la région occidentale du Cuba. Compte Rendu, Congrès géologique international, XIe, Stockholm, pp. 1021-1022.
- DE LORIOL, P. 1903. Étude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du Jura lédonien. 2eme partie, 14 pls., Abhandlungen der schweizerischen paläontologischen Gesellschaft, Mémoires de la Société Paléontologique Suisse, XXX, pp. 77-160, Pls. vi-xix.
- D'ORBIGNY, ALCIDE. 1842. Paléontologie Française. Terrains Oolitiques ou Jurassiques. Tome I, Paris, 642 pp., Atlas 1842-49, 234 plates.
1845. Géologie de la Russie d'Europe et des Montagnes de l'Oural, II, part 3, Paléontologie.
- FAVRE, ERNEST. 1875. Description des Fossiles du Terrain Jurassique de la Montagne des Voirons (Savoie). Mem. Soc. Pal. Suisse, II, 77 pp. 7 plates.
1876. Description des Fossiles du Terrain Oxfordien des Alpes Fribourgeoises, Mem. Soc. Pal. Suisse, III, 75 pp., 7 plates.
- HAUG, ÉMIL. 1885. Beiträge zu einer Monographie der Ammonitengattung Harpoceras. Neues Jahrbuch für Min. Geol. u. Pal., Beilage Bd. III, pp. 585-722, Pls. xi, xii.
- HEALEY, MAUD. 1904a. Notes on Upper Jurassic Ammonites, with special reference to specimens in the University Museum, Oxford, No. 1. Quarterly Journal Geological Society, London, LX, pp. 54-64, Pls. ix-xii. (Types refigured and redescribed: *Perisphinctes plicatilis* (Sow.), *P. biplex* (Sow.), *P. variocostatus* (Buckland), *Olcostephanus pallasianus* (d'Orb.), new var.)
- 1904b. *Ammonites plicatilis* Sowerby. Palæontologia universalis, Ser. I, Fasc. III, Pls. LVII, LVIII. (Refiguring of holotype, suture line redrawn on T 1 b of Pl. LVII.)

- NEUMANN, JOHANN. 1907. Die Oxfordfauna von Cetechowitz. Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients, Wien und Leipzig, XX, pp. 1-67, Pls. I-VIII, and 2 text figures.
- OPPEL, ALBERT. 1862-63. Palaeontologische Mittheilungen aus dem Museum des königlichen bayerischen Staates. Stuttgart, 1862, Pt. III, Ueber jurassische Cephalopoden, pp. 127-262, Pls. XL-LXXIV.
1866. Über die zone des *Ammonites transversarius*. Geognostisch-Paläontologischen Beiträge von Benecke, Schloenbach und Waagen. München. pp. 207-316. (Table showing distribution of ammonites in zone of *transversarius*.)
- OPPENHEIMER, JOSEF. 1907. Der Malm der Schwedenschanze bei Brünn. Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients, Wien und Leipzig, XX, pp. 221-271, Pls. XX-XXII.
- PHILLIPS, JOHN. 1829. Illustrations of the Geology of Yorkshire; or, a Description of the Strata and Organic Remains of the Yorkshire Coast, accompanied by a Geological Map, Sections, and Plates of the Fossil Plants and Animals. York. 192, pp., geol. map, 14 plates.
- QUENSTEDT, FRIEDRICH AUGUST. 1843. Das Flozgebirge Württembergs. Tübingen, 558 pp.
1846. Petrefactenkunde Deutschlands. Die Cephalopoden. Tübingen, 580 pp., Atlas, 36 plates, 1849.
1858. Der Jura. Tübingen, 842 pp., 100 plates.
1885. Die Ammoniten des schwäbischen Jura. Stuttgart. 1140 pp., Atlas, 126 plates.
- RIAZ, A. DE. 1898. Description des Couches à *Pelloceras transversarium* (Oxfordien Supérieur) de Trept-(Isère), 69 pp., 19 plates.
- SEEBACH, KARL. 1864. Der Hannoversche Jura. Berlin, 158 pp., 10 plates, map. (Map of Hannover with Jurassic outcrops.)
- SIEMIRADZKI, JOSEF VON. 1898-99. Monographische Beschreibung der Ammonitengattung Perisphinctes. Palaeontographica, XLV, pp. 69-352, Pls. XX-XXVII, and 85 text figures.
- SOWERBY, JAMES. 1818. Mineral Conchology of Great Britain, Vol. II, London, 1818, accompanying plates in vol. VIII.
- WAAGEN, WILLIAM. 1875. Jurassic Fauna of Kutch. Palaeontologia Indica, Calcutta, (9) I, 247 pp., 60 plates.
- ZIETEN, C. J. v. 1830-33. Die Versteinerungen Württembergs. Stuttgart, 102 pp.; atlas, 72 plates. (*A. canaliculatus* p. 37, *A. plicatilis* p. 9.)

PLATE XXXIV

Fig. 1. *Perisphindes cubanensis*, new species. Holotype: lateral view. P. 648.
A. M. N. H. No. 18556.

Fig. 2. *Perisphindes cubanensis*, new species. Holotype: ventral view.
A. M. N. H. No. 18556.

Fig. 3. *Perisphindes cubanensis* mutation α , new mutation. Holotype: lateral
view. P. 660. A. M. N. H. No. 18557.

Fig. 4. *Perisphindes cubanensis* mutation α , new mutation. Holotype: ventral
view. A. M. N. H. No. 18557.

HORIZON: Lower zone of the Upper Oxfordian, Upper Jurassic.

LOCALITY: Viñales, Province of Pinar del Rio, Cuba.

All of the figures are natural size.



1



2



3



4

PLATE XXXV

Fig. 1. *Perisphinctes cubanensis* mutation β , new mutation. Holotype: lateral view. P. 662. A. M. N. H. No. 18558.

Fig. 2. *Perisphinctes cubanensis* mutation β , new mutation. Holotype: ventral view. A. M. N. H. No. 18558.

Fig. 3. *Perisphinctes delatorii*, new species. Holotype: lateral view showing portions of six volutions. P. 663. A. M. N. H. No. 18559.

Fig. 4. *Perisphinctes delatorii*, new species. Holotype: lateral view showing whorls separated. A. M. N. H. No. 18559.

(a) Portions of first four volutions, showing early stages with simple costæ.

(b) Portion of fifth volution, showing costæ bifurcating.

(c) Portion of sixth volution, showing adult arrangement of costæ.

and fig. 5. *Perisphinctes delatorii*, new species. Holotype: cross-section of whorl and dorsal view of sixth whorl. A. M. N. H. No. 18559.

Fig. 6. *Perisphinctes delatorii*, new species. Holotype: view showing whorls broken along septa. Innermost whorl exposed smooth on venter.

A. M. N. H. No. 18559.

HORIZON: Lower zone of the Upper Oxfordian, Upper Jurassic.

LOCALITY: Viñales, Province of Pinar del Rio, Cuba.

All of the figures are natural size.



1



2



5



6



c



3



b



a

4

PLATE. XXXVI

Fig. 1. *Perisphinctes plicatiloides*, new species. Holotype: lateral view, slightly enlarged. P. 670. A. M. N. H. No. 18560.

Fig. 2. *Perisphinctes plicatiloides*, new species. Holotype: ventral view, showing median groove in internal mold, the costæ being unchanged in direction in crossing the venter. Natural size. Compare with Fig. 3. A. M. N. H. No. 18560.

Fig. 3. *Idoceras soteloi* Burckhardt. Plesiotype: ventral view, showing orad bending of costæ and their complete interruption in both shell and internal mold along the median ventral zone. Natural size. Specimen in Palæontological Museum, Columbia University.

Fig. 4. *Idoceras soteloi* Burckhardt. Plesiotype: lateral view of same specimen shown in Fig. 3. Natural size.

HORIZON: Original of Figs. 1 and 2 from lower zone of the Upper Oxfordian, Upper Jurassic. Original of Figs. 3 and 4 from *Idoceras* zone of the Kimmeridgian, Upper Jurassic.

LOCALITIES: Original of Figs. 1 and 2 from Viñales, Province of Pinar del Río, Cuba. Original of Figs. 3 and 4 from Mazapil, Mexico.



1



2



3



4

PLATE XXXVII

Fig. 1. *Ochetoceras canaliculatum* (von Buch) var. *burckhardti*, new variety.
Holotype: lateral view. Natural size. P. 681. A. M. N. H. No. 18561.

Fig. 2. *Ochetoceras canaliculatum* (von Buch) var. *burckhardti*, new variety.
Holotype: ventral view, showing outline of keel and ventral angles. Natural size.
A. M. N. H. No. 18561.

Fig. 3. *Ochetoceras canaliculatum* (von Buch) var. *burckhardti*, new variety.
Holotype: lateral view enlarged about three and one-half times to show suture,
growth-lines, and character of keel. A. M. N. H. No. 18561.

HORIZON: Upper zone of the Upper Oxfordian, Upper Jurassic.

LOCALITY: Viñales, Province of Pinar del Río, Cuba.



PLATE XXXVIII

Fig. 1. *Ochetoceras mexicanum* Burckhardt. Plesiotype: lateral view. Natural size. P. 686. A. M. N. H. No. 18562.

Fig. 2. *Ochetoceras mexicanum* Burckhardt. Plesiotype: ventral view, showing siphuncle in cross-section and outline of keel. Natural size. A. M. N. H. No. 18562.

Fig. 3. *Ochetoceras mexicanum* Burckhardt. Plesiotype: lateral view, enlarged about two and one-half times to show suture, character of costæ, lateral groove, and keel. A. M. N. H. No. 18562.

Fig. 4. *Ataxioceras virgulatus* (Quenstedt). Plesiotype: lateral view. Natural size. A. M. N. H. No. 18563.

Fig. 5. *Ataxioceras virgulatus* (Quenstedt). Plesiotype: ventral view. Natural size. A. M. N. H. No. 18563.

HORIZON: Upper zone of the Upper Oxfordian, Upper Jurassic.

LOCALITY: Viñales, Province of Pinar del Rio, Cuba.



3



1



2



5



4

Article XVII.—STAPHYLINIDÆ FROM FLORIDA IN THE COLLECTION OF THE AMERICAN MUSEUM OF NATURAL HISTORY, WITH DESCRIPTIONS OF NEW GENERA AND SPECIES¹

BY HOWARD NOTMAN

PLATE XXXIX

***Lispinus tenuis* LeConte**

This species is given as a synonym of *L. tenellus* Erichson, in the Junk-Schenkling Catalogue. Erichson's species was described from Colombia, South America and the West Indies and he uses the adjective nitidus (shining), whereas LeConte's species is described as subnitidus (feebly shining). The specimens at hand are very distinctly longitudinally strigose and dull in lustre and it seems very probable that they should be regarded as a species distinct from *L. tenellus*.

Miami, March 10.

***Thoracophorus costalis* (Erichson).**

Punta Gorda, November 17; (Leng). Enterprise, October 25, November 15, "under bark."

***Omalium humerosum* (Fauvel).**

Enterprise, October 19.

TROGOPHEUS Mannerheim

***Trogophæus maculicollis*, new species**

Form rather slender, parallel, subdepressed. Color dark castaneous; head and abdomen blackish; thorax with a large, nubilous blackish spot on the disk, extending to the apical margin; basal joint of the antennæ and the legs pale flavate. Pubescence very fine and inconspicuous. Integuments slightly shining on elytra and abdomen, distinctly less so on the thorax and head. Head and thorax very finely but strongly granulate-punctate, the margin of the thorax granulose. Punctures on the elytra clearly separated but very close, one-half their diameters apart, fine, shallow, umbilicate. Punctuation of the abdomen like that of the elytra but distinctly finer and denser. Head slightly transverse, a little narrower than the thorax. Antennal tuberculations strong, eyes large, moderately convex, coarsely granulate; tempora straight, one-third the diameter of the eyes, distinctly but obtusely angulate. Antennæ slightly longer than the head and thorax, feebly incrassate; second and third joints elongate, subequal; fourth and fifth just visibly elongate; the tenth as long as

¹In the preparation of this paper especial acknowledgements are due to Mr. C. W. Leng for the privilege of using the proof-sheets of his new 'List of the Coleoptera of North America' which has greatly expedited the work. Acknowledgements are also due to Col. T. L. Casey, Mr. E. T. Cresson, Jr., Librarian of the American Entomological Society, and to Mr. A. J. Mutchler of The American Museum of Natural History.

wide. Thorax four-fifths the width of the elytra, one-third wider than long, widest at apical third where the sides are narrowly rounded, thence straight and strongly convergent to the apical angles which are produced, subdentiform; slightly more strongly convergent and feebly sinuate to the base which is slightly more than one-half the greatest width and very distinctly narrower than the apex; disk rather distinctly bi-impressed. Elytra just perceptibly wider than long, about one-third longer than the thorax, strongly longitudinally impressed near the suture. Abdomen narrower than the thorax, distinctly wider to the apex of the fourth segment; sides feebly arcuate. Length, 2.45-2.8 mm.; width, .5-.6 mm. Twenty-three specimens.

Type, labeled "Fla." Seven paratypes: 2, Cape Sable; 1, Key West; 4, labeled "Fla." Other specimens, Enterprise, November 22 and December 12; Titusville, November 8, at light; (Lutz).

This species is closely related to *fulvipes* Erichson described from Porto Rico. Erichson, however, states that in *fulvipes* the apical margin of the elytra is often paler. No trace of this is to be found in the twenty-two specimens at hand, not even in a pale-colored immature example. The elytra are in fact distinctly somewhat nubilously darker in the outer apical angles. The dark cloud on the thorax, also, is entirely constant. *T. texanus* Casey, which is given as a synonym of *fulvipes*, differs by its broader thorax and more widely spaced elytral punctures and probably more rounded tempora.

***Trogophloeus basicornis*, new species**

Form somewhat robust and convex. Color dark castaneous; head and abdomen black; tarsi, tibiae, and basal joint of the antennae pale flavate. Integuments rather shining. Head and thorax with the punctures fine, distinct, separated by about half their diameters; punctures of the elytra twice the diameters of those on the thorax and separated by more than their diameters; the punctures somewhat bronzed; abdomen rather strongly micro-reticulate but very finely and sparsely punctate. Head scarcely transverse, very slightly narrower than the thorax; antennal tuberculations not very strong; eyes small but convex and coarsely granulate; tempora equal in length to the eye, strongly rounded and equally prominent. Antennae as long as the head and thorax, slender, second joint almost as long as the next two and very much thicker, as thick as the first; third joint distinctly, fourth very slightly elongate; ninth and tenth joints distinctly larger, as long as wide. Thorax about three-fourths the width of the elytra, one-third wider than long, widest before the middle, sides nearly parallel anteriorly, rounded and nearly straight posteriorly, base about two-thirds the greatest width; angles not distinct, discal impressions very feeble. Elytra scarcely transverse, about one-half longer than the thorax, sutural impressions very feeble. Abdomen slightly narrower than the elytra at base, subparallel to the apex of the fifth segment. Length, 1.75-2 mm.; width, .4 mm. Three specimens.

Type and paratype, labeled "Fla." and one specimen, Enterprise, September 14.

This species is related to *T. nanulus* Casey and *T. modestus* Casey but differs by its slender antennae with the outer joints not transverse. The antennal structure is like that of *T. corticinus* Grav. and *T. gracilis*

Mannerheim European specimens of which are at hand. The basal joint in *corticinus* is dark, however, and the fourth joint in *gracilis* is smaller and distinctly transverse. In both these species the elytra are longer than wide.

Oxytelus insignitus Gravenhorst.

Chokoloskee, April 8; South Bay, Lake Okeechobee, May 1, beating; Everglade, April 15, in traps; (Grossbeck).

Oxytelus nanus Erichson.

Gainesville, October 1, under cow dung; Monticello, October 8, in cheese traps; (Mutchler).

BLEDIUS Stephens

Series *Armati*

1. Flanks of the thorax convex.....2.
- Flanks of the thorax concave along the side margins.....5.
2. Thorax scarcely wider than long; lateral thoracic angles obsolete.....3.
- Thorax distinctly wider than long, two-fifths to one-third; lateral thoracic angles distinct.....4.
3. Head narrower; elytra rufo-piceous; size larger, 5.5-6 mm.....*armatus* Say.
- Head wider, nearly as wide as the thorax; elytra piceous black; size smaller, 4.3-4.9 mm.....*arizonensis* Fall.
4. Apex of the thorax truncate; apical angles distinct.....*strenuus* Casey.
- Apex of the thorax broadly rounded; apical angles broadly rounded
furtivus Casey.
5. Under surface of the thorax without an impressed line parallel to the margin..6.
- Under surface of the thorax with an impressed line parallel with the margin..8.
6. Elytra finely and densely punctate.....7.
- Elytra coarsely and less densely punctate.....*nigriceps*, new species.
7. Elytra much longer than the thorax.....*fenyesi* Bernhauer.
- Elytra scarcely as long as the thorax.....*monstratus* Casey.
8. Median line of the thorax indistinct and incomplete.....9.
- Median line of the thorax distinct, entire.....11.
9. Head without a tubercle but with a fovea.....10.
- Head with a tubercle on the vertex; without a fovea.....*consimilis* Fall.
10. Thorax opaque.....*flavipennis* LeConte.
- Thorax shining.....*ineptus* Casey.
11. Thorax finely punctate.....12.
- Thorax coarsely punctate.....14.
12. Elytral punctuation closer; punctures separated by about their own diameter 13.
- Elytral punctuation sparser; punctures separated by more than twice their diameter.....*agonus* Casey.

13. Median thoracic line feebly impressed; head finely and strongly punctate; elytra one-third longer than the thorax.....*lectus* Casey.
Median thoracic line more strongly impressed; head with few fine and scattered punctures; elytra one-fifth longer than the thorax.....*episcopalis* Fall.
14. Head without a tubercle.....15.
Head with a prominent divided tubercle.....*gradatus* Fall.
15. Head with an impression on the vertex.....16.
Head without any impression on the vertex.....*politus* Erichson.
16. Dorsal line of the thorax fine, feebly impressed.....17.
Dorsal line of the thorax wide and very deeply impressed.....*eximius* Casey.
17. Elytra finely and densely punctate.....*cuspidatus* LeConte.
Elytra feebly, sparsely, and somewhat coarsely punctate.....*tenuis* Casey.

***Blodius nigriceps*, new species**

Form rather slender, parallel, strongly convex. Color of head black; abdomen piceous black; thorax rufous; elytra testaceous, rather broadly blackish along the suture; antennæ rufous, legs testaceous. Head moderately shining, uniformly, finely but strongly granulate-reticulate; thorax and elytra very strongly shining, thorax very feebly reticulate near the margins; abdomen moderately shining, rather feebly reticulate. Head about four-fifths the width of the thorax, feebly convex, without punctures; antennal tubercles large and strong; anterior angles of the epistoma with small but strong and acute teeth; vertex with a rather large, broadly rounded tuberculation; epistomal suture fine, arcuate, scarcely impressed. Antennæ reaching the middle of the thorax; third joint as long as the second, as long as the next two; tenth joint one-third wider than long. Thorax as wide as the base of the elytra, four-fifths the width of the apex, as wide as long, sides parallel and straight for apical two-thirds thence broadly rounded to the base, lateral and basal angles completely rounded; apex subtruncate, apical angles rounded; disk very sparsely, unevenly, rather coarsely and indistinctly punctate; median line wide, entire and strongly impressed. Elytra about one-fourth longer than wide, suture about one-fourth longer than the thorax, sides nearly straight; glabrous, punctures coarse but not dense, separated by somewhat less than their diameters. Abdomen parallel to the apex of the fourth segment, not as wide as the elytra, nearly impunctate. Length, 4-4.5 mm.; width, .75-1 mm. ♂, ♀. Seven specimens.

Type and five paratypes, Fort Meyers, March 30, at light; (Grossbeck). One specimen from the type locality.

Series Semiferruginei

1. Basal thoracic angles rounded, indistinct.....2.
Basal thoracic angles not rounded, somewhat prominent.....*turgidus* Casey.
2. Thoracic episterna not triangular, sutures parallel with the side margin of the under surface of the thorax.....3.
Thoracic episterna very distinctly triangular, sutures directed to the front angles of the pronotum.....6.
3. Dorsal line of the thorax present.....4.
Dorsal line of the thorax wanting.....5.

4. Dorsal line faint.....*analis* LeConte.
Dorsal line well impressed.....*piceus* Fall.
5. Thorax very densely punctate; punctures moderate in size....*assimilis* Casey.
Thorax coarsely but not densely punctured.....*nitidicollis* LeConte
6. Sides of the thorax very much rounded.....7.
Sides of the thorax slightly rounded, nearly parallel in front.....9.
7. Head not or obsoletely punctured.....8.
Head coarsely punctured.....*semiferrugineus* LeConte.
8. Thorax wider than long, densely punctured.....*rotundicollis* LeConte.
Thorax not wider than long, more coarsely punctured.....*fumatus* LeConte.
9. Head shining, not reticulate.....10.
Head more or less dull.....13.
10. Head punctured.....11.
Head impunctate except for the median fovea.....12.
11. Head and thorax sparsely not very coarsely punctured; thorax longer than wide
nitidiceps LeConte.
Head and thorax very coarsely and rather closely punctured; thorax as long as
wide.....*canaliculatus*, new species.
12. Thorax feebly reticulate laterally.....*specularis* Fall.
Thorax strongly granulate-reticulate throughout.....*regularis* Fall.
13. Thorax more or less strongly reticulate, dull.....14.
Thorax not or feebly reticulate, more or less strongly shining.....16.
14. Black, elytra paler. Head more or less distinctly punctate. Median thoracic
line more or less strongly impressed.....15.
Black. Head impunctate; median thoracic line fine.....*opacifrons* LeConte.
15. Tenth antennal joint as long as wide; sides of the thorax straight anteriorly.
tallaci Fall.
Tenth antennal joint slightly transverse; sides of the thorax slightly arcuate
anteriorly.....*philadelphicus* Fall.
16. Thorax and abdomen black.....17.
Abdomen rufo-testaceous, thorax more or less darker.....19.
17. Outer antennal joints more or less transverse; thorax finely reticulate; head
uniformly reticulate.....18.
Outer antennal joints not transverse; thorax not reticulate; area contiguous
to the cephalic fovea polished.....*foraminosus* Casey.
18. Elytra distinctly longer than the thorax, suture one-fifth longer, brownish black;
antennal joints less transverse; thoracic episterna less narrowed anteriorly,
width at the front angles one-half that at the coxal fissures...*deceptivus* Fall.
Elytra scarcely longer than the thorax, rufo-castaneous, blackish on the base
and suture; antennal joints more transverse; thoracic episterna more
narrowed anteriorly.....*relictus* Fall.
19. Thorax coarsely and densely punctured.....*rubiginosus* Erichson.
Thorax finely and sparsely punctured.....*gravidus* Casey.

Blodius canaliculatus, new species

Form rather slender, parallel, convex. Color rufo-piceous, head and thorax black; antennæ and legs rufo-testaceous, the former slightly infusate distally. Integument's shining throughout; abdomen, only, feebly and partially reticulate. Head as wide as the thorax; eyes large and very convex; antennal and epistomal tubercles feeble; epistomal suture distinctly impressed; a feeble impunctate tuberculation on the vertex with a fovea behind it; sides of the front with numerous large, rather deep punctures separated by less than their diameters, those on the clypeus less distinct. Antennæ long and slender, nearly reaching the base of the thorax; third joint slightly shorter than the second; fourth and fifth elongate, fourth scarcely shorter than the third, fifth slightly shorter than the fourth; outer joints gradually and very moderately larger; tenth as long as wide. Thorax as long as wide, three-fourths as wide as the elytra, sides in the anterior two-thirds straight and parallel thence broadly rounded posteriorly, angles and base completely obsolete; apex just visibly arcuate, apical angles rounded. Median line rather wide but feebly impressed; punctures large, deep, separated by about their diameters, showing a marked tendency to canaliculation especially on the sides. Elytra as long as wide, on the suture about one-fifth longer than the thorax; punctures distinctly smaller than those on the thorax but as closely placed, evenly distributed; pubescence whitish, rather long and conspicuous but not dense, that on the abdomen longer and pale fulvous. Abdomen scarcely narrower than the apex of the elytra, sides subparallel to the apex of the fourth segment; punctures fine and very sparse dorsally, more numerous, rather coarser but very indistinct ventrally. Length, 5 mm.; width, 1 mm. One specimen.

Type, Fort Myers, March 30, at light; (Grossbeck).

Blodius punctatissimus LeConte.

Pablo Beach (on the beach just above high-tide mark), November 4, in or under dung, boards, etc.; Punta Gorda, November 16, sweeping grasses on edge of standing rain-pool; (Leng).

Blodius basalis LeConte.

Dunedin, March 4; (Blatchley). Pablo Beach (on the beach just above high-tide mark), November 4, in or under dung, boards, etc.; (Leng).

Blodius dimidiatus LeConte.

Enterprise, October 1.

Blodius cordatus (Say).

Marco, April 17, at light; (Grossbeck).

Osorius politus LeConte.

Titusville, November 8; (Lutz).

OSORIUS Latreille**Osorius brevicornis**, new species

Form elongate, parallel, cylindrical. Color black; front of the head, antennæ, legs, thorax and elytra rufous; elytra slightly paler. Head feebly reticulate, shining with rather numerous, moderate-sized and somewhat indistinct punctures, divided by a median smooth line of moderate width; thorax still more feebly reticulate, strongly shining, with irregular series of elongate punctures divided medially by a

smooth line, punctures slightly larger and more distinct than those on the head, not very closely placed, separated by more than their diameters; elytra strongly shining but somewhat rugose with the punctuation rather indistinct except near the base where the punctures are about the size of those on the thorax; abdomen rather more finely and closely punctured but not rugose. Head slightly transverse, as wide as the thorax, strongly arcuato-angulate anteriorly, front and vertex evenly convex; eyes small, distant more than their diameters from the base. Antennae short, rather stout scarcely reaching the middle of the thorax; first joint very long, as long as the next five; second joint stout, about one-half longer than wide; third shorter, but slightly elongate, one-fourth as long as wide; fifth and sixth globular, visibly transverse; remaining joints suddenly somewhat larger, all transverse, eight to ten one-third wider than long; terminal joint very slightly elongate, a little longer than the tenth; mentum trap zoidal, scarcely transverse, narrower in front, strongly granulose. Thorax closely connate with the head, a very little longer than wide, sides somewhat strongly narrowed posteriorly, feebly arcuate, apical angles acute, basal rounded. Elytra parallel, scarcely wider or longer than the thorax, distinctly impressed along the suture. Abdomen as wide as the elytra at base, sides straight and distinctly divergent to the apex of the fifth segment where it is distinctly wider than any part of the body. Length, 4.5 mm.; width, .75 mm. One specimen.

Type, Pensacola, October 11, sweeping; (Mutchler).

This species may be distinguished from *O. latipes* Erichson as represented by a Kentucky specimen agreeing with Erichson's description, by its color, more indistinctly punctured head and elytra, abdomen wider posteriorly, but especially in the antennal structure. The outer joints in *O. latipes* are as long as wide and the funicular joints all visibly elongate; the third is nearly twice as long as wide, whereas the third in *O. brevicornis* is not more than one-fourth longer.

STENUS Latreille

***Stenus teter*, new species**

Form rather slender. Pubescence short and fine, very inconspicuous. Head rather small, twice as wide as long; interocular lines meeting at about two lengths in advance; interocular surface rather broad, slightly more than twice the width of the eye; sulcations broad, rather shallow, separated by a short, not very prominent, but highly polished tuberculation; punctures rather coarse and close, separated by about one-half their diameters, more or less coalescent in groups of two or three; interspaces very shining. Antennae somewhat longer than the width of the head; basal joints black, the remainder dark piceous; slender; joints three to seven decreasing gradually in length, seventh a little stouter, eighth very slightly elongate, club moderate; maxillary palpi dark piceous throughout, moderate in length. Thorax nearly one-third longer than wide, widest a little in front of the middle where it is three-fourths the width of the head, thence nearly straight and slightly convergent to the anterior angles, convergent and distinctly sinuate to the posterior angles, apex arcuate, equal in width to the base which is nearly straight; surface rather uneven, more or less distinctly impressed on the sides, with a fine, almost linear, median canaliculation which is subentire; punctures rather coarse, slightly larger than those of the head,

unevenly distributed, closer and more or less canaliculate in the lateral impressions where they are separated by half their diameters, more widely spaced in irregular median areas; interspaces highly polished. Elytra at base just visibly wider than the head, as wide as long, suture one-fifth longer than the thorax, sides parallel, feebly arcuate; surface very uneven, strongly impressed along the suture; a humero-discal impression and an apico-lateral impression; punctures similar in size and arrangement to those on the thorax. Abdomen nearly as wide as the elytra at base, very gradually decreasing in width to the apex of the fourth segment, punctuation fine and confined more or less to the sides of the segments; transverse carinae four-cuspid, the cusps sub-similar. Legs rather long and slender, dark piceous, first joint of the posterior tarsi as long as the next two, a little shorter than the last, fourth simple. Length, 3.75-4.25 mm.; width, .7-.8 mm. ♂, ♀. Two specimens.

Male.—Fifth ventral segment just perceptibly sinuate at middle, sixth with a very broad and shallow emargination, occupying the whole width of the segment, seventh segment truncate with a rather long acute tooth at either end.

Female.—Sixth segment broadly rounded.

Type male and allotype female, Enterprise, December 15, "débris, L. shore."

This species is evidently related to *S. pluto* Casey. It may be distinguished by its narrower elytra with coarser punctuation and uneven surface and by its narrower and more elongate thorax.

***Stenus sectilifer* Casey.**

Titusville, November 8; (Lutz). Punta Gorda, November 16; (Leng).

***Stenus meridionalis* (Casey).**

Enterprise, November 22, December 12 and 15. Fort Meyers, November 15, at roadside pool, apparently rather permanent; (Lutz).

***Stenus callosus* Erichson.**

Monticello, October 8, dredging lakes in cypress swamp at Lake Micesoukee; (Mutchler). Titusville, November 8, in a roadside pond, probably part of a wet-weather run; (Lutz).

***Stenus lutzii*, new species**

Form slightly robust, convex. Subglabrous. Integuments very highly polished. Head large, twice as wide as long; interocular surface flat, twice as wide as the eye; ocular lines meeting at about one length in advance; a median, fusiform, impunctate callosity on the vertex and indistinct callosities either side near the eye; supra-antennal ridges smooth and polished; punctures moderate in size and close-set, separated by about one-third their diameters. Antennae longer than the width of the head, slender, rather pale brownish testaceous; club darker, third joint nearly as long as the next two which are of equal length and distinctly longer than the sixth; seventh incrassate, elongate; eighth slightly transverse; ninth and tenth subequal in length; terminal joint much longer. Thorax three-fourths the width of the head, widest at the middle where it is just visibly narrower than long, sides arcuate and

convergent anteriorly, equally convergent and sinuate posteriorly, apex arcuate and equal to the base which is much less arcuate. Punctures coarse, distinctly larger than those on the head, more widely and unevenly spaced on the disk, with a median, fusiform, highly polished smooth area, on the sides separated by about half their widths. Elytra strongly convex, at base slightly narrower than the head, suture slightly longer than the thorax, conjointly slightly transverse, sides rather strongly divergent posteriorly so that the apex is distinctly wider than the head; suture feebly impressed, punctures equal in size to those on the thorax, sparse along the suture, more dense laterally where they are separated by about their diameters; sides strongly rounded apically. Abdomen much narrower than the elytra, unmargined; transverse carinæ without cusps; segments rather closely punctured in the basal impressions, nearly impunctate apically, punctures much finer than those on the elytra. Legs of moderate size; basal joint of the posterior tarsi as long as the next three, fourth deeply bilobed; color pale brownish testaceous, femora indefinitely darker to the knees. Length, 3 mm.; width, .75 mm. One specimen.

Female.—Sixth ventral segment evenly rounded posteriorly.

Type female, Monticello, October 8, dredging lakes in cypress swamp, at Lake Micesoukee; (Mutchler).

This species is very distinct from *S. callosus* Erichson by its large head, short transverse elytra, with the sides strongly divergent posteriorly and the slightly darker legs with indefinitely infusate femoral apices.

***Pinophilus latipes* Gravenhorst.**

Fort Meyers, March 30, April 1 and 22 at light; (Grossbeck).
Key West.

***Palaminus testaceus* Erichson.**

Enterprise, October 25.

***Palaminus contortus* LeConte.**

Lake Island, February 25; (Blatchley).

***Gastrolobium bicolor* (Gravenhorst).**

Enterprise, November 22.

***Hesperobium cinctum* (Say).**

Fort Meyers, March 30, at light; (Grossbeck).

***Pæderus littoreus* Austin.**

Clearwater, April 30; (Van Duzee). Newberry, November 18,
under boards, near pines in sandy field; (Leng).

***Pæderus floridanus* Austin.**

Fort Meyers, November 12, at light; (Lutz).

***Pæderus obliteratus* LeConte.**

Sanford, April 4; (Blatchley). Enterprise, November 12, December 12.

TETARTOPEUS Czwalina**Tetartopeus nigriceps, new species**

Form elongate, subfusiform, scarcely convex. Color piceous, head black, elytra with the outer apical angles sharply testaceous; labrum, mouth-parts and the two basal joints of the antennæ rufous; legs dull testaceous; the apex of the abdomen not distinctly paler; apical joint of the antennæ paler. Head to the bases of the antennæ as wide as long, orbicular; the eyes moderate in size, at less than twice their diameters from the base. Head behind the eyes convergent throughout, in the female perfectly circular, in the male the base is just visibly truncate and the sides feebly subangulate; neck one-third the width of the head, surface distinctly, more or less closely punctate with a smooth area on the vertex, rather coarse punctures mixed with fine. Antennæ even in thickness, attaining the base of the thorax; first joint considerably longer; the second slightly shorter; the third somewhat longer than the remaining which are of equal length, about twice as long as wide. Gular sutures at apex separated by about one-eighth the width of the head, straight and slightly convergent to the base; under side of the head not closely, rather finely and indistinctly punctured. Thorax scarcely wider than the head (♂), just visibly so (♀), a little less than one-third longer than wide, about two-thirds the width of the elytra, sides very feebly arcuate (♂), absolutely parallel (♀); angles all equally moderately rounded, surface rather coarsely and closely punctate with a smooth median line equal in width to the thickness of the first antennal joint. Elytra a little less than one-third longer than wide, just visibly more elongate in the female; the suture a sixth longer than the thorax, sides parallel, apex somewhat strongly emarginate, surface strongly and rather closely punctate, the punctures very slightly smaller than those on the thorax. First joint of the posterior tarsi distinctly shorter than either the second or the third. Length, 8 mm.; width, 1.4–1.5 mm. ♂, ♀. Two specimens.

Type male and paratype female, labeled "Fla."

Male.—The second ventral segment of the abdomen slightly flattened and glabrous medially, the third, fourth, and fifth longitudinally impressed, the sixth with a rather deep and narrow and acutely triangular emargination about one-third the length of the segment. The sixth dorsal broadly rounded.

Female.—The sixth ventral segment with a broad lobe, at base two-thirds the width of the segment, broadly rounded at the apex, length about two-thirds that of the segment. The sixth dorsal segment strongly angulate.

The shape of the head in this species allies it to *T. nigrescens* Casey but the sexual characters are those of *T. angularis* LeConte from which it differs considerably in proportions.

Pseudolathra analis (LeConte).

Enterprise, December 15.

Linolathra dimidiata (Say).

Enterprise, December 12 and 15.

Lathrobiella ventralis (LeConte).

Enterprise, November 17, December 12 and 14.

Lithocharis ochracea (Gravenhorst).

Enterprise, October 12, November 22.

SCIOCHARIS Arribáizaga

(Sciopharella Casey)

Sciocharis (Sciopharella) quadriceps, new species.

Form elongate, moderately slender, rather depressed. Color brownish testaceous; head darker, tinged with piceous; elytra paler, testaceous. Body evenly, finely, rather indistinctly micro-reticulate and punctate throughout, punctures little more than a circular ring with a minute hair at the center; lustre feebly shining. Head to the bases of the antennae slightly transverse; sides parallel, base truncate, posterior angles moderately rounded; eyes round, moderate in size, distant somewhat more than their own diameters from the base. Labrum narrowly and deeply emarginate medially with a denticle either side of the emargination. Antennae as long as the head and thorax; first two joints greatly thickened; second nearly as long as the next two. Gular sutures well separated at base, about one-seventh the width of the head, parallel for a short distance then arcuate and rather strongly divergent to the base. Neck a little less than one-half the width of the head. Thorax as wide as long, about four-fifths the width of the elytra, visibly narrower than the head, base and apex equally moderately arcuate, angles rounded, anterior slightly more distant than the basal. Elytra scarcely wider than the head, slightly longer than the thorax, about one-fourth longer than wide, sides parallel, apex distinctly emarginate. Abdomen a little narrower than the elytra, parallel to the apex of the fourth segment. Prosternum not carinate, somewhat convex medially. Anterior tarsi not dilated; four basal joints of the posterior tarsi subequal in length, terminal joint as long as the preceding three. Length, 2.5-2.75 mm.; width, .4 mm. ♂, ♀. Nine specimens.

Male.—Fifth ventral abdominal segment with a broad, short median lobe, not quite one-third the width of the segment; sixth with a deep, cuspidiform median emargination.

Type male and allotype female, labeled "Fla." Paratypes: four, Enterprise, October 12 and 19, rubbish; three, labeled "Fla."

This species differs from *S. delicatula* Casey in its larger size, larger eyes and narrower, somewhat elongate elytra.

Scopæus carolinæ Casey.

Enterprise, October 27, November 1 and 19, "débris, L. shore."

Scopæus macilentus Casey.

Enterprise, October 25.

Scopæopsis opaca (LeConte).

Enterprise, November 19 and 22, Titusville, November 8, sifting leaves in forest; (Lutz).

Stillicus angularis Erichson.

Enterprise, October 15 and 19.

Stannoderus pallidus Casey.

Enterprise, October 19, "palm."

Astenus binotatus (Say).

Punta Gorda, November 16, sifting débris on beach of Charlotte Harbor; (Leng).

Astenus spectrum (Casey).

Enterprise, November 15, December 12.

Astenus fusciceps (Casey).

Cape Sable.

Leptogenius brevicornis Casey.

Enterprise, December 15.

Gyrophypnus temporalis (LeConte).

Enterprise, December 12.

Gyrophypnus luteiventris Casey.

Newberry, November 18, beating pine; (Leng).

Lithocharodes nigripennis (LeConte).

Enterprise, October 19, November 19 and 22, December 12.

Diochus schaumii Kraatz.

Enterprise, December 12, 14 and 15. Titusville.

OPHIOÖMMA, new genus

Labial palpi with the penultimate joint large, somewhat inflated; terminal joint very small, elongate, parallel, the apex truncate. Maxillary palpi with the penultimate joint with short, coarse hairs, oval, internal edge more arcuate, the apex oblique; the terminal joint very small, conical, acute.

Head broad, flattened, quadrangular, front truncate; labrum large, strongly obliquely truncate either side with a deep triangular, median emargination; antennæ inserted at the apical angles of the epistoma, some distance before the eyes, not closely approximate. Eyes small, distant from the base; neck narrow; one-third the width of the head; gular sutures approximate anteriorly, arcuate and strongly divergent posteriorly, separated at the base by one-third the width of the head. Antennæ short, distinctly capitate; first joint stout elongate, second very short. Mandibles with strong tooth near the apex.

Thorax with the side margin acute, entire, becoming inferior anteriorly; prosternum truncate at apex, moderate before the coxæ, which are separated by a thin vertical lamina which attains the mesosternum; cavities moderately open.

Intermediate coxæ contiguous; mesosternum rather long, posterior projection acute between the coxæ, with a large, round, deep, median fovea; metasternum short, posterior coxæ conical, prominent, contiguous.

Abdomen inflated, segments gradually increasing in length posteriorly.

Legs slender and moderate in length.

Antennæ and legs pubescent.

This genus seems best placed in the Xantholini with the genus *Hyptioma* Casey from which it is distinguishable by its divergent gular sutures, narrow neck, capitate antennæ and foveate mesosternum.

Ophioömma rufa, new species

Form elongate, parallel, somewhat ventricose. Color uniform dull rufous; legs and antennæ scarcely paler. Pubescence short, pale, inconspicuous. Head and thorax with the punctures rather fine, separated on both by a narrow impunctate median line; punctures without arrangement, more dense on the sides of the head behind the eyes. Punctures on the elytra coarser and more distinct, slightly rugulose. Abdomen finely, evenly, rather indistinctly and not closely punctate. Head behind the antennæ about one-fourth wider than long; eyes small, not prominent, at more than twice their diameters from the base, sides nearly straight, slightly divergent posteriorly, posterior angles rather narrowly rounded; base truncate; front strongly narrowed before the eyes; antennæ separated at base by a little more than one-third the width of the head. Head beneath with large, widely spaced, perforate punctures bearing setæ. Antennæ reaching the middle of the thorax; first joint stout, elongate; second one-half the length of the first, as long as wide, equal in length to the third and stouter; joints four to eight moniliform; the last three abruptly slightly larger; nine and ten slightly transverse; eleven scarcely as long as the two preceding, not much longer than wide, acutely pointed. Thorax just visibly narrower than the head; widest at the apex where it is just visibly wider than long; apex arcuate, anterior angles obtuse but distinct, sides nearly straight and slightly convergent to the broadly rounded posterior angles; base scarcely truncate, distinctly pedunculate. Elytra slightly narrower than the thorax at base, as wide at apex; sides straight, conjointly about one-fourth wider than long; suture not overlapping, four-fifths the length of the thorax. Abdomen as wide as the elytra at base with the sides broadly arcuate, widest at the apex of the third segment where it is distinctly wider than the head. Anterior tarsi dilated and pubescent beneath. Posterior tarsi with the first joint elongate, as long as the next two and also as the terminal joint; joints two to four of equal length. Length, 2.3 mm.; width, .5 mm. Two specimens.

Type and paratype, Punta Gorda, November 16, sifting débris on beach of Charlotte Harbor; (Leng).

This species resembles the smaller *Lathrobia*, but seems structurally related to the *Xantholini*.

Cafius bistriatus (Erichson).

Punta Gorda, November 11, sifting débris on shore at mouth of Peace River, at high-tide mark, November 12; (Leng).

Neobisnius umbripennis (LeConte).

Enterprise, October 12, November 22. Pebbly Beach, Jacksonville, May 9.

Actobius cinerascens (Gravenhorst).

Enterprise, November 1 and 22, December 12 and 14.

Actobius parvus Horn.

Enterprise, October 15.

Philonthus hepaticus Erichson.

Enterprise, September 17 and 21, October 1, November 22. Punta Gorda, November 12, sifting débris on beach of the Charlotte Harbor at high-water mark; (Leng).

Philonthus flavolimbatus Erichson.

Enterprise, September 17, October 12.

Philonthus gopheri Hubbard.

Three specimens marked "Fla." and three Enterprise, October 15, one of these labeled "Gophers Hole."

Philonthus alumnus Erichson.

Enterprise, October 19, November 22, December 15. Fort Meyers, April 22; Everglade, April 9, at light; (Grossbeck).

Philonthus fulvipes (Fabricius).

Sanford, May; (Van Duzee).

Philonthus lomatus Erichson.

Enterprise, December 12 and 14. Key West.

Belonuchus formosus (Gravenhorst).

Three specimens in which the head and thorax are entirely red, do not differ in other respects from those typically colored.

Enterprise, October 16, December 12. Cape Sable. New River.

Creophilus maxillosus var. **villosus** (Gravenhorst).

Enterprise, November 1. Fort Meyers, April 26, from a hog's head; (Grossbeck).

Tanygnathus bicolor Casey.

De Funiak Springs, October 17, under board; (Mutchler).

Acylophorus pronus Erichson.

Enterprise, December 14.

Tachyporus macropterus Stephens.

Enterprise, September 14, October 16 and 25, November 22.

Erchomus ventriculus (Say).

Key West.

Erchomus laevis (LeConte).

Dunedin, January 15 (Blatchley). Enterprise, December 14.

Conosoma ornatum (Sharp).

Two specimens agree in all respects with the description of the above species, with the exception of slight differences in color which Sharp states is variable.

Enterprise, September 22.

Conosoma basalis Erichson.

Enterprise, November 15 and 22.

Conosoma scriptus (Horn).

Enterprise, November 20.

Bryoporus rufescens LeConte.

Ortega, near Jacksonville, November 3, sifting thin leaf covering, mainly pine needles, of sandy soil; (Leng).

Boletobius pygmaeus (Fabricius).

Pensacola, October 13, in mushroom fungus; (Mutchler).

Deinopsis myllænoides Kraatz.

Enterprise, November 11.

MYLLÆNA Erichson

The following synopsis of this genus, being based in large part on descriptions alone, must be considered somewhat tentative. European specimens of the three European species listed from North America are at hand. In regard to *Myllæna minuta* Gravenhorst, it should be noted that the following phrase is used in the original description: "Coleoptra elytris quadratis"; and that in the preceding description of *Aleochara* (*Myllæna*) *dubia* the following phrase is used: "Coleoptra elytris latitudine paulo longioribus, subquadratis" (Gravenhorst, Mon. Col. Microp., pp. 174-176). Erichson, in the 'Genera et Species Staphylinorum' (pp. 209-211), does not give the proportions of the elytra; and Ganglbauer, in the 'Kafer von Mitteleuropa,' in the generic diagnosis, states: "Die Flügeldecken so lang oder kurzer als der Halsschild:" in his descriptions of the species *dubia* and *minuta*, he states: "Flügeldecken so lang als der Halsschild." In specimens of five European species sent to the author, including those noted, the elytra are conjointly distinctly transverse.

In regard to *Myllæna vulpina* Bernhauer it should be noted that the original description (Deutsche Ent. Zeits., 1907, p. 381.) states: "Die Flügeldecken länger als der Halsschild." Blatchley in the 'Coleoptera of Indiana,' however, states: "The elytra as wide and as long as thorax." The specimens at hand identified as *vulpina* Bernhauer agree with Blatchley's description in this point.

Because of the excellence of Col. Casey's descriptions, the author feels justified in offering the following synopsis as an aid to the student of this somewhat obscure genus.

1. Elytra not distinctly shorter than the thorax.....2.
Elytra distinctly shorter than the thorax; suture not more than four-fifths the length of the latter.....18.
2. Antennæ longer; the tenth joint one-half or more longer than wide.....3.
Antennæ shorter; the tenth joint at most one-fourth longer than wide.....11.
3. Thorax narrow, one-third wider than long.....4.
Thorax broader, about one-half wider than long.....6.
Thorax still broader, three-fifths wider than long.....*insipiens* Casey.

4. Head large, three-fifths the width of the thorax; antennæ dark.5.
Head smaller, one-half the width of the thorax; antennæ pale.
vulpina Bernhauer.
5. Posterior angles of the thorax more obtuse, not prominent; antennæ longer.
intermedia Erichson.
Posterior angles of the thorax prominent; antennæ shorter.*fuscipennis* Kraatz.
6. Posterior thoracic angles projecting slightly posteriorly.7.
Posterior thoracic angles not projecting posteriorly.*procidua* Casey.
7. Size larger; more than 2 mm.; fifth abdominal segment one-half as wide as the
base.8.
Size small; 1.4–1.6 mm. Fifth abdominal segment nearly three-fourths as wide
as the base. Abdomen less narrowed posteriorly.*arcana* Casey.
8. Thoracic base broadly arcuate and sinuate laterally.9.
Thoracic base feebly arcuate; elytral sinuses large and deep.10.
9. Basal angles of thorax right; elytral sinuses unusually feeble.*insomnis* Casey.
Basal angles of thorax strongly obtuse; elytral sinuses deep.*dubia* Gravenhorst.
10. Pubescence uniform; eleventh antennal joint much shorter than the two preced-
ing; elytral suture nearly as long as the thorax.*dissimulans* Casey.
Pubescence not uniform, longer erect hairs mixed with the dense decumbent
pubescence; eleventh antennal joint nearly as long as the two preceding;
elytral suture very slightly shorter than the thorax.*molesta* Casey.
11. Head small, about one-half as wide as the thorax.12.
Head larger, not less than three-fifths as wide as the thorax.14.
12. Thorax narrower, less than one-half wider than long; elytra not longer than the
thorax.13.
Thorax broader, three-fifths wider than long; elytra longer than the thorax.
umbra Casey.
13. Thorax a little less than one-half wider than long, widest a little behind the
middle; sides straight thence to the apex. Abdomen more strongly nar-
rowed; fifth segment distinctly less than one-half the width of the base.
currax, new species.
Thorax one-third wider than long; sides evenly arcuate from base to apex.
Abdomen less narrowed; fifth segment rather more than one-half the width
of the base.*minuta* Gravenhorst.
14. Head smaller, three-fifths the width of the thorax.15.
Head larger, two-thirds the width of the thorax; surface somewhat shining,
punctures less dense.17.
15. Thorax narrow, one-third wider than long.16.
Thorax broader, three-fifths wider than long; punctures everywhere very dense.
esuriens Casey.
16. Posterior thoracic angles rounded; antennal joints slightly longer than wide.
cuneata, new species.

- Posterior thoracic angles distinct; antennal joints almost wider than long.
senyesi Bernhauer.
17. Thorax with sides evenly arcuate; basal angles feebly prominent posteriorly.
frivola Casey.
Thorax widest behind the middle; base without lateral sinuations; posterior
angles broadly rounded.....*obscurata* Casey.
18. Thorax more transverse, three-fifths or more wider than long..... 19.
Thorax less transverse, not much more than one-half wider than long..... 21.
19. Head larger, three-fifths as wide as the thorax..... 20.
Head smaller, one-half as wide as the thorax.....*scobinella* Casey.
20. Elytra shorter, suture two-thirds the length of the thorax. Abdomen more
narrowed; fifth segment but little more than one-half as wide as the base.
Lustre more shining.....*impellens* Casey.
Elytra longer, suture four-fifths the length of the thorax. Abdomen less nar-
rowed; fifth segment nearly two-thirds as wide as the base. Lustre duller.
brevicollis Casey.
21. Antennæ more elongate; tenth joint one-half or more longer than wide..... 22.
Antennæ less elongate; tenth joint about as long as wide or slightly wider than
long..... 25.
22. Head small, one-half as wide as the thorax..... 23.
Head larger, three-fifths as wide as the thorax.....*immunda* Casey.
23. Elytra longer; suture about four-fifths as long as the thorax..... 24.
Elytra shorter; suture but little more than two-thirds as long as the thorax.
vegeta Casey.
24. Size smaller, 2 mm. Abdomen less narrowed; fifth segment more than one-half
as wide as the base; angulation of the sixth segment in the male twice as
long. Lustre dull.....*abdita* Casey.
Size larger, 2.55 mm. Abdomen more narrowed; fifth segment rather less than
one-half as wide as the base; angulation of the sixth segment in the male a
little shorter than its basal width. Lustre more shining....*audax* Casey.
25. Punctuation moderately dense. Thorax with the base slightly sinuate laterally.
The fifth abdominal segment slightly more than one-half as wide as the
base..... 26.
Punctuation very dense. Thorax with the base not sinuate laterally. The
fifth abdominal segment three-fifths or more the width of the base..... 27.
26. Thorax wider, one-half wider than long.....*decreta* Casey.
Thorax narrower, less than one-third wider than long.....*infuscata* Kraatz.
27. Color piceous-black. Elytra longer, three-fourths the length of the thorax.
Vestiture not uniform; longer erect hairs mixed with the decumbent pubes-
cence.....*ludificans* Casey.
Color paler brown. Elytra shorter, two-thirds the length of the thorax. Pubes-
cence uniform.....*brevivestis* Casey.

***Myllæna cuneata*, new species**

Rather slender, moderately convex, somewhat shining. Color piceous; basal portions of the five basal segments blackish; antennæ and legs slightly paler. Pubescence fine, pale decumbent and uniform. Punctures fine and dense. Head large, three-fifths as wide as the thorax. Antennæ (♂) moderately long, slightly incrassate; the outer joints about one-fifth longer than wide, the terminal joint wider, acutely pointed, not as long as the two preceding. Thorax slightly less than one-third wider than long, feebly and evenly arcuate from base to apex; base scarcely arcuate, lateral sinuations just perceptible; posterior angles obtuse and rather broadly rounded. Elytra parallel, distinctly transverse, equal in width to the thorax; the suture very slightly shorter, the lateral sinuses deep. Abdomen slightly narrower than the elytra, strongly narrowed, the fifth segment scarcely one-half the width of the base, the sixth with the apical angulation in the male broader than long; the apex strongly rounded. Length, 1.5–1.75 mm.; width, 4.5 mm. ♂, ♀. Fifteen specimens.

Type male and allotype female, labeled "Fla." Paratypes: 3 labeled "Fla." 3 Enterprise, November 19 and December 12. Other specimens, Enterprise, November 22.

***Myllæna currax*, new species**

Not stout, moderately convex, somewhat shining. Color piceous, basal portions of the five basal segments of the abdomen blackish; antennæ and legs scarcely paler; pubescence and punctuation as in the preceding. Head one-half as wide as the thorax. Antennæ (♀) distinctly thicker than in the preceding; joints less elongate; the tenth very slightly longer than wide; eleventh about as long as the preceding two. Thorax slightly less than one-half wider than long, widest a little behind the middle, sides thence straighter and rather strongly convergent to the apex, slightly convergent to the posterior angles which are obtuse but very distinct; base as in the preceding. Elytra parallel, transverse, as wide as the thorax; the suture about as long as the thorax; the apical sinuses deep. Abdomen as in the preceding but with the apical angulation of the sixth segment broader, nearly twice as wide as long. Length, 2 mm.; width, .5 mm. ♀. One specimen.

Type, Enterprise, December 12.

***Myllæna infuscata* Kraatz.**

One specimen labeled 'Fla.'

***Oligota parva* Kraatz.**

Enterprise, September 22, October 5 and 19.

Group SILUSÆ

Dr. Fenyès places ten genera in this group (Gen. Ins., Fasc. 173A, p. 7). The following synopsis of these genera is constructed from the descriptions. Several of them do not mention certain characters of importance. The synopsis is therefore conjectural in certain points. Kiesenwetter does not state the proportions of the ligula in relation to the first joint of the labial palpi in *Halmæusa*. Bernhauer does not give the

proportions of the tarsal joints in *Parasilusa* nor are they given in the descriptions of *Pectusa*, *Eudiestota* and *Eusipalia*. In *Diestota*, Rey States that the end joint is equal in length to the three preceding. It seems a fair inference to suppose that the proportions are normal in those genera in which they are not given. The genera in the last section cannot be satisfactorily separated with the characters given. In *Parasilusa* the ligula is said to be divided to the middle, but the prosternum is not described. The ligula is not mentioned in the others. Notwithstanding these defects sufficient data is given to show the relationships of the proposed genus.

1. Mesos'ternum acute at apex; middle coxæ narrowly separated.....2.
Mesos'ternum broad between the coxæ; truncate or slightly rounded at apex...5.
2. Ligula entire.....3.
Ligula bifid at apex.....*Schistacme*, new genus.
3. Ligula less elongate, not surpassing the first joint of the labial palpi.....4.
Ligula very elongate, surpassing the first joint of the labial palpi.
Linoglossa Kraatz.
4. Last joint of the maxillary palpi one-half longer than the penultimate.
Halmæusa Kiesenwetter.
Last joint of the maxillary palpi equal in length to the penultimate.
Silusa Erichson.
5. Terminal joint of the intermediate tarsi longer than the three preceding united.....6.
Terminal joint of the intermediate tarsi not longer than the three preceding united.....8.
6. Pros'ternum simple; mesosternum extending to the middle of the coxæ.....7.
Pros'ternum carinate; mesos'ternal process extending to two-thirds the length of the coxæ; infralateral carinæ distinct.....*Tomoxelia* Bernhauer.
7. Abdominal segments strongly impressed; fourth and fifth of equal length; infralateral carinæ very indistinct.....*Apheloglossa* Casey.¹
First three abdominal segments finely and very feebly impressed; fifth much shorter than the fourth; infralateral carinæ fine but entire...*Pectusa* Casey.¹
8. Prosternum simple.....9.
Prosternum compresso-carinate.....*Eudiestota* Sharp.
9. Metasternum not foveolate.....10.
Metasternum between the intermediate coxæ foveolate....*Eusipalia* Sharp.
10. Ligula divided to the middle.....*Parasilusa* Bernhauer.
Ligula entire. Antennæ with joints six to ten very strongly transverse, almost perfoliate. Head exerted.....*Diestota* Rey.

¹Col. Casey supplies the following concerning the genera *Apheloglossa* and *Pectusa*: "In *Apheloglossa* the prosternum is not carinate. In *Pectusa* the last joint of the middle tarsi is longer than the first three combined by about a third. The prosternum is not carinate and the ligula is apparently entire and rather pointed."

SCHISTACME, new genus

Maxillæ elongate, not very narrow; the inner lobe about three times as long as wide, widest at two-thirds its length, very slightly narrowed to base, strongly narrowed to apex which bears a narrow acute tooth projecting inward; the apical third of the inner edge carries about ten, long, bristle-like teeth; the outer lobe is slightly longer than the inner but no thicker, the apex is bluntly rounded and ciliate for about one-quarter of its length; the lobe is slightly bent at apical third.

Maxillary palpi four jointed; the second and third joints are subequal in length, not very incrassate; the third is about twice as wide as long, a little wider than the second, and strongly narrowed in less than basal third; the very narrow subulate fourth joint is about one-half the length of the third.

Mandibles broad at base, apex rather long, narrow and strongly bent, the inner edge obtusely angulate near the base and finely serrate from a little before the angulation to the apical tooth; the teeth become gradually less distinct toward the apex. (There is a deep fissure in the inner edge of the left mandible at the base of the apical tooth giving it the appearance of an appendiculate tarsal claw. The fissure is apparently lacking in the right mandible.)

Ligula moderately elongate, narrow, bifid at apex; paraglossæ not apparent.

Labial palpi two jointed; joints of equal length, elongate, first joint surpassing the ligula.

Mentum broad, truncate at apex, slightly narrowed in front.

Infralateral carinæ strong, entire.

Labrum short, twice as wide as long, truncate, with a small rather shallow median notch.

Prosternum broadly angulate posteriorly with a small acute point at middle and a strong median carina.

Mesosternum simple; intermediate coxæ narrowly separated, projection long and acute, more than two-thirds the length of the coxæ, fitting over the metasternal projection which is also acute.

Coxal cavities rather small, marginal bead entire.

Last joint of the intermediate tarsi not quite as long as the three preceding; basal joints of the posterior tarsi elongate, decreasing gradually in length; first shorter than the next two.

Tibiæ setose.

Antennæ short, strongly incrassate.

Schistacme obtusa, new species

Plate XXXIX, Figure 1

Form moderately stout, slightly convex. Color pale rufo-testaceous. Rather shining. Punctuation and pubescence coarse, not at all close; punctures on the head umbilicate, elsewhere asperate, less numerous on the fifth segment, surface alutaceous throughout. Head rather large, transverse, a little more than one-half the width of the thorax, slightly wider than the thorax at apex; eyes moderate, not projecting, distant from the base a little less than their own diameters. Antennæ not as long as the head and thorax; first joint stout, oval, one-third longer than wide; second and third elongate, twice as long as wide, obconic, third a little shorter and more slender than the second; fourth globular; fifth one-half wider; sixth two-thirds

wider; tenth twice as wide as long. Terminal joint conical, apex obtusely rounded, nearly as long as the preceding three. Antennæ not conspicuously setose. Thorax three-fifths wider than long, just perceptibly wider than the elytra, rather convex, without impressions, narrowed anteriorly, sides evenly and rather strongly arcuate, base broadly arcuate and feebly sinuate laterally; posterior angles obtuse, broadly rounded. Elytra parallel, transverse, conjointly one-half wider than long; the suture slightly shorter than the thorax, apex very feebly emarginate, apical sinuses moderately deep. Abdomen very slightly narrower than the elytra, moderately narrowed posteriorly, fifth segment three-fourths the width of the base; three basal segments with feeble transverse impressions. Length, 1.5 mm.; width, .45 mm. Eleven specimens. ♂, ♀.

Male.—Sixth dorsal segment of the abdomen broadly biemarginate, tricusped; sixth ventral with a strong median triangular projection one-third the width of the segment, at base a little broader than long, apex rounded with a few closely placed hairs.

Female.—Sixth dorsal segment of the abdomen with a very broad median emargination, four times as broad as deep.

Type male, labeled "Fla."; allotype female, Enterprise, November 15. Nine paratypes: 6 Enterprise, November, 15, "bark"; 3 labeled "Fla."

Enterprise, November 15, "bark".

***Thecturota fracta* Casey.**

Enterprise, September 14, October 15; November 15, December 12, "rubbish."

***Thecturota nevadica* Casey.**

Enterprise, November 22.

It is surprising to find specimens of the above two species of *Thecturota* described from Arizona and Nevada respectively, in Florida material, but the descriptions fit so perfectly that identification seems certain.

Group BOLITOCARÆ

1. Infralateral carinæ of the head lacking or very incomplete.....2.
Infralateral carinæ of the head present and entire.....3.
2. Size larger; mesosternum carinate.....*Bolitochara* Mannerheim.
Size very small; mesosternum not carinate.....*Caloderina* Ganglbauer.
3. Mesosternum not or incompletely carinate.....4.
Mesosternum carinate; carina entire.....*Ditropalia* Casey.
4. Head feebly narrowed posteriorly.....5.
Head strongly narrowed posteriorly.....*Gastrophæna* Fauvel.
5. Mesosternal projection broad anteriorly, rapidly narrowed, its apex narrowly rounded or subacute, free and separated from the metasternal projection by a considerable longitudinal discontinuity; basal joint of the hind tarsi scarcely as long as the next two combined.....*Phymatura* Sahlberg
Mesosternal process longer, narrow and more parallel, free and rounded at tip, virtually attaining the apex of the metasternal projection; basal joint of the hind tarsi fully as long as the next two combined....*Silusida* Casey.

SILUSIDA Casey**Silusida tenuicornis**, new species

Plate XXXIX, Figure 10

Form very moderately stout, scarcely convex. Color pale rufo-testaceous; outer joints of the antennæ infusate; elytra and fourth abdominal segment blackish; elytral humeri and basal segments of the abdomen paler, testaceous. Punctuation moderately fine, distinct, rather close; abdomen more shining, punctuation scarcely discernible. Pubescence fine, not conspicuous. Head transverse, nearly one-half wider than long, about four-fifths the width of the thorax; eyes rather large but not prominent; genæ two-thirds the length of the eye, moderately convergent, neck very broad; infralateral carinæ strong, entire. Ligula elongate, deeply bifid at apex. Labial palpi three-jointed, second joint shorter. Antennæ rather long and slender, gradually very moderately incrassate distally; second and third joints of equal length; second twice as long as wide, third slightly more slender; fourth, fifth and seventh as long as wide; sixth slightly elongate; eighth to tenth just visibly transverse, strongly obconic. Terminal joint long oval, as long as the three preceding. Thorax two-thirds wider than long, slightly narrower than the elytra, widest at middle, sides feebly convergent and arcuate in front, straight and slightly less convergent to the posterior angles which are very obtuse but distinct; base broadly rounded; hypomera visible from the side. Elytra slightly divergent, slightly more transverse than the thorax; suture slightly longer than the thorax. First and second abdominal segments strongly transversely impressed; third less so. Intermediate coxæ rather broadly separated; mesoventral projection short, not reaching the middle of the coxæ, broadly rounded at apex, separated from the metasternal projection which is narrower and more acute. Four basal joints of the posterior tarsi elongate, equal in length. Terminal joint as long as the preceding three. Length, 2 mm.; width, .7 mm. Two specimens. ♂, ♀.

Male.—Sixth dorsal abdominal segment deeply emarginate either side, the median projection between the emarginations one-third wider than long, rectangular, broadly and feebly emarginate at apex with a small tooth at the center of the emargination; apical angles of the projection rounded and strongly thickened. Outer angles of the lateral emarginations produced inwards as strong teeth which partially enclose the emarginations. Side margins of the segments with a small terminal tooth. Ventral segments unmodified.

Female.—Without modifications.

Type male, labeled "Fla." Allotype, female, Enterprise, September 14.

This species is very distinct by reason of the structure of the antennæ, hind tarsi, and the peculiar male abdominal modifications. These differences do not seem quite sufficient, however, to demand the erection of a new genus.

ELACHISTARTHRONINI, new tribe

This new tribe is erected to contain the two new genera *Elachistarthron* and *Orthodiatelus* here described. It is characterized by the tarsal formula 4-4-5, eleven-jointed antennæ, four-jointed maxillary palpi, and one-jointed labial palpi. The two genera may be separated as follows.

1. Intermedesocoxal projections rounded at apex; the meta, distinctly narrower than the meso; terminal joint of the intermediate tarsi as long as the three preceding.....*Elachistarthron*, new genus.
2. Intermedesocoxal projections wider, subequal in width, their apices contiguous on a straight transverse suture; terminal joint of the intermediate tarsi very distinctly longer than the three preceding.....*Orthodiatelus*, new genus.

ELACHISTARTHON, new genus

Maxillæ moderately elongate, lobes rather less than three times as long as wide of equal length, outer lobe entirely membranous, inner lobe obliquely truncate in apical two-fifths; digitus short and inconspicuous; a longer and more prominent tooth at basal end of the truncature; edge of the truncature with very short bristle-like teeth, a few long bristle-like setæ below the truncature, both lobes straight.

Maxillary palpi four-jointed, second and third joints strongly incrassate, subequal in length, the third slightly thicker, suboval, twice as long as wide. Terminal joint subulate but unusually long and thick, slightly more than one-half the length of the third.

Ligula small slender, briefly divided at apex.

Labial palpi one-jointed, long, slender, parallel; apex rounded.

Mandibles much broadened at base, apex strongly curved, acuminate, inner edge with a minute tooth about two-fifths from the apex.

Mentum large, trapezoidal, about one-third wider than long, apex three-fifths the width of the base, feebly emarginate, angles rounded, bilaterally impressed.

Eyes large, moderately prominent; tempora short, inconspicuous, one-half the diameter of the eyes. Infralateral carinæ strong, entire; gular sutures widely separated, diverging to the base.

Antennæ short, gradually moderately incrassate; third joint shorter than the second.

Prosternum very short; projection broadly triangular. Intermediate coxæ rather widely separated, mesosternal projection about two-fifths the length of the coxæ, broadly rounded at apex, almost contiguous with the metasternal projection which is longer and somewhat narrower, also rounded at the apex.

Thoracic hypomera visible from the side. Metepisterna narrow, parallel.

Legs moderately long, basal tarsal joints subequal. Terminal joint equal in length to the preceding three.

***Elachistarthron ambiguum*, new species**

Plate XXXIX, Figures 2 and 7

Form moderately elongate, subparallel, subdepressed. Color brownish testaceous; thorax and abdomen slightly paler, tinged with rufous. Moderately shining, surface finely reticulate, punctures on head, thorax and elytra moderately coarse and rather dense; abdomen much more shining, surface with fine, sparse and indistinct punctures; pubescence rather long, decumbent and conspicuous throughout. Head moderately transverse, nearly one-third wider than long, as wide as or slightly wider than the thorax; tempora slightly convergent; front convex. Antennæ as long as the head and thorax; first joint, oval, twice as long as wide, slightly thicker but no longer than the second which is more obconic; third one-fourth shorter than the

second; fourth as long as wide; fifth to tenth gradually more transverse; tenth more than twice as wide as long. Terminal joint as long as the three preceding, oval, apex very broadly rounded. Thorax four-fifths the width of the elytra, three-fifths wider than long, widest at apical third, very feebly arcuate anteriorly and straight posteriorly to the posterior angles which are very obtuse but distinct; base feebly and somewhat angularly arcuate, a narrow and rather feeble transverse impression before the scutellum. Elytra conjointly about one-fourth wider than long, suture nearly one-half longer than the thorax, sides parallel, apex not emarginate, sinuses not evident. Abdomen narrower than the elytra at base, sides very broadly and evenly arcuate, fifth segment distinctly longer than the others, three basal segments with strong transverse impressions, that on the fourth feeble. No sexual differences noted. Length, 1.4–1.6 mm.; width, .4 mm. Eight specimens.

Type and paratypes, labeled "Fla.," except one paratype labeled Enterprise, December 12.

ORTHODIATELUS, new genus

Maxillæ with the lobes rather long and slender, well separated; outer lobe membranous, slightly longer than the inner, ciliate at apex; inner lobe about four times as long as wide, evenly, arcuately narrower from base to apex, digitus very small, inner edge with short teeth on apical third, a few long cilia below.

Maxillary palpi four-jointed, second and third joints rather short, moderately incrassate, third thicker, subulate fourth joint two-thirds as long as the third. Labial palpi very long, slender, linear, on-join'ed.

Ligula bifid at apex, moderately long, slender, linear.

Mentum trapezoidal, about one-third wider than long; apex two-thirds the width of the base, feebly circularly emarginate, strongly rugose at base.

Eyes large, convex; tempora short convergent; infralateral carinæ strong, entire; gular sutures rather widely separated, very slightly divergent to the base, sinuate.

Antennæ rather short, rather gradually and strongly incrassate distally; third joint scarcely shorter but more slender than the second, outer joints transverse.

Prosternum very short, simple. Intermediate coxæ widely separated; inter-mesocoxal processes equal in width, contiguous in a straight transverse suture at about the middle of the coxæ.

Thoracic hypomera visible from the side throughout their length. Metepisterna parallel.

Tarsi with the basal joints of subequal length; terminal joint of the intermediate tarsi very distinctly longer than the preceding three.

Orthodiatelus innotabilis, new species

Plate XXXIX, Figures 3, 9, and 11

Form slender, parallel, subdepressed. Color piceous brown, apical abdominal segments gradually blackish; basal antennal joints and legs paler. Integuments rather closely and distinctly micro-reticulate. Head, thorax, and elytra distinctly and rather densely punctate; head slightly less densely; punctures on the abdomen very sparse; pubescence moderate in length and coarseness; abdomen with longer and more bristle-like hairs; lustre rather dull throughout. Head about one-third wider than long, slightly narrower than the base of the thorax; eyes large moderately

convex, tempora convergent, about one-half the diameter of the eyes. Antennæ as long as the head and thorax; first joint slightly thicker, elongate; fourth joint very slightly transverse; outer joints gradually more transverse; tenth joint twice as wide as long; terminal joint wider, conical, apex rather blunt, longer than the preceding two. Thorax four-fifths the width of the elytra, two-thirds wider than long, widest at the middle, apex distinctly narrower than the base; sides anteriorly feebly arcuate, posteriorly nearly straight and subparallel, base rounded, indistinctly sinuate laterally; posterior angles obtuse but distinct, disk convex, very faintly impressed before the scutellum. Elytra conjointly nearly one-third wider than long, suture about one-fourth longer than the thorax, sides parallel, apex not emarginate, sinuses very feeble. Abdomen slightly narrower than the elytra at base, subparallel to the apex of the fourth segment; fifth segment with the sides slightly converging; three basal segments with strong transverse impressions, that on the fourth less distinct. Length, 1.8-2 mm.; width, .5 mm. ♂. Two specimens.

Male.—Sixth dorsal abdominal segment with six large parallel-sided, rounded teeth on the middle of the apical margin, separated by a longer interval from a longer and more acute lateral tooth.

Female.—Unknown.

Type, Enterprise, October 12. Paratype, labeled "Fla."

The two genera *Elachistarthron* and *Orthodiatelus* are closely related to each other and probably to the genera *Amenusa* Casey, *Pectusa* Casey, and *Diestota* Rey. Casey states that the head is exerted in *Diestota mayeti* Rey, the type species of that genus, and that the species is intermediate in its characters between the *Gyrophænæ* and the *Bolitocharæ* (Trans. Acad. Sci. St. Louis, 1906, p. 279). The form of the intermesocoxal parts in *Elachistarthron* separates it from the other genera named. *Pectusa* Casey differs from *Orthodiatelus* in the fine and feeble impressions of the basal abdominal segments, these impressions being confined to the first three only. This is also a characteristic of *Amenusa*. In *Pectusa* the fifth abdominal segment is much shorter than the fourth, but in *Amenusa* and *Orthodiatelus* these two segments are of equal length. In *Pectusa* and *Amenusa* the infralateral carinæ are very fine or even obsolescent; in *Orthodiatelus* they are rather coarse and entire.

Sharp has described a number of species from Mexico and Central America which he assigns to the genus *Diestota*. Casey, in the passage cited above, expresses doubt as to Sharp's correctness in so assigning them. Of these species one has the same rather striking male modifications of the sixth abdominal segment found in *Orthodiatelus*. This species, *D. laticornis* (Biol. Cen. Amer., I, part 2, p. 248), which seems to differ somewhat distinctly from the others, may prove to be congeneric with *Orthodiatelus innotabilis*. It is described as a short species of fine and feeble punctuation and pubescence, probably strongly shining, since it is said to resemble *Atheta testaceipes* Heer. It is black in color with pale elytra. The third joint of the antennæ is said to be short.

Elachistarthron ambiguum and *Orthodiatelus innotabilis* resemble each other very closely in form. They have a strong athetid facies and would be taken for members of that genus. They resemble *A. coriaria* Kraatz but are quite distinctly more slender and parallel.

The ligula in these two species is apparently like that of the *Bolitocharæ* being bifid at apex. The labial palpi have been examined under quite favorable circumstances and it seems to the author that it would be hyperinferential to call them other than one-jointed.

Eumicrota corruscula (Erichson).

Enterprise, October 23.

***Eumicrota anomala*, new species**

Plate XXXIX, Figure 8

Form very short and broad. Color very dark piceous; antennæ, mouth-parts and legs pale testaceous; abdomen black. Integumen's moderately shining, micro-reticulate. Head and thorax moderately closely but very indistinctly punctate; elytral punctures distinct but not more dense. Head one-half wider than long; eyes moderately large; tempora not apparent. Maxillæ moderate in length, outer lobe membranous, elongate, not wider at base, about three times as long as wide, inner lobe rather broadly oval, inner edge arcuate from base to apex, digitus not distinct, thickly set with minute spines from basal third to apex. Maxillary palpi four-jointed, second and third joints subequal, third strongly incrassate, second feebly incrassate; subulate terminal joint long and rather thick, about two-thirds the length of the third. Ligula short and broad, shorter than the first joint of the labial palpi, rounded at apex. Labial palpi two-jointed, joints elongate, second joint two-thirds the length of the first and distinctly more slender; joints even in thickness. Menium large, slightly transverse, narrowed in front, apex broadly bilobed. Antennæ as long as the head and thorax; first joint elongate, slightly incrassate; second two-thirds the length of the first and slightly more slender; third two-thirds the length of the second and about one-half as wide; fourth globular, slightly wider; fifth to tenth very gradually wider, fifth just perceptibly transverse, tenth about one-third wider than long. Terminal joint conical, moderately acute at apex, as long as the preceding two. Thorax slightly wider than the head, twice as wide as long, slightly narrowed in front, base broadly arcuate and laterally sinuate. Elytra slightly wider than the thorax, one-half wider than long, slightly divergent posteriorly, suture as long as the thorax. Abdomen slightly narrower than the elytra at base, moderately narrowed posteriorly. Intermediate coxæ widely separated, meso- and meso- and meso-ernum solidly united between them, the suture straight and transverse, a little behind the middle. Basal joint of the intermediate tarsi slightly longer than the following, terminal as long as the three preceding; four basal joints of the posterior tarsi subequal in length, terminal joint equal to the two preceding. No sexual difference is observable in the specimens at hand and they are probably all females. Length, 1 mm.; width, .4 mm. Sixteen specimens.

Type and nine paratypes, Monticello, eastern arm of Lake Miconsoukee, October 8, in fungus; (Mutchler).

Other specimens from the type locality and one from Enterprise, November 12.

***Eumicrota insolita*, new species**

Resembles the preceding, may be distinguished by its slightly less transverse thorax, less narrowed anteriorly, antennæ shorter, fourth joint slightly transverse, feebler and sparser punctuation; abdomen less narrowed posteriorly and generally paler coloration. Length, .9–1.4 mm.; width, .3–.4 mm. Thirteen specimens.

Type, labeled "Fla." Five paratypes: 3, labeled "Fla."; 2, Monticello, eastern arm of Lake Micesoukee, October 8, in fungus; (Mutchler). One, Enterprise, September 12. Other specimens Enterprise, September 20, November 20.

These two species on account of their antennal structure would not be included in *Eumicrota* as defined by Col. Casey. They do not seem distinct enough in other respects to require more than a section of the genus.

***Gyrophæna floridana* (Casey).**

Enterprise, September 11 and 24, October 16. Pensacola, October 13 and 14, in fungus, Monticello, October 5, on horse skeleton; (Mutchler).

***Gyrophæna lætula* Casey.**

Monticello, October 5, on horse skeleton; (Mutchler).

Tribe HOPLANDRIINI

In volume I of his Memoirs, p. 174, Col. Casey makes the following statement: (*Hoplandria*) "*pulchra* Kr., does not seem to be strictly congeneric with *ochracea*, if the sexual characters are correctly described; I have not seen it." Specimens of a species evidently closely allied to *pulchra* Kraatz are in the material at hand. Since no structural differences other than those of sexual modifications and of form are discernible between this species and specimens believed to be *H. lateralis* Melsheimer (Pl. XXXIX, fig. 5) collected at Windsor, N. Y., an examination of the maxillæ was resorted to. These parts of the mouth have been considered of great importance in generic distinctions in the Aleocharinæ by Kraatz and other students. Considerable differences in the form of the inner lobe were found, which are set forth in the following descriptions, and have led the author to introduce a new genus as suggested by Col. Casey.

1. Innermediate coxæ not contiguous.....2.
Innermediate coxæ contiguous.....*Tetrallus* Bernhauer.
2. Basal joints of the posterior tarsi of unequal length.....3.
Basal joints of the posterior tarsi of equal or subequal length.....5.
3. Mesosternum not carinate. (Male with conspicuous processes or carinæ on the elytra and abdomen.).....4.
Mesosternum carinate. (Male without conspicuous processes or carinæ on the elytra and abdomen.).....*Tinotus* Sharp

4. Basal joint of the posterior tarsi almost twice as long as the second; inner lobe of the maxillæ simply ciliate with a free slender extremity having a minute supplementary joint.....*Platonica* Sharp.
Basal joint of the posterior tarsi slightly longer than the second; inner lobe of the maxillæ with long, coarse cilia and a long strongly curved digitus.
Platandria Casey.
5. Mesosternum not carinate.....6.
Mesosternum carinate.....*Exaleochara* Keys.
6. Eyes moderate in size, tempora distinct; ligula bifid. (Clypeus in the male without a longitudinal carina.).....7.
Eyes large, tempora not distinct; ligula entire. (Clypeus of the male with a strong longitudinal carina.).....*Lophomuclet*, new genus.
7. Free corneous extremity of the inner lobe of the maxillæ short, straight, apex rounded without digitus. (Male with a carina at the inner apical angles of the elytra.).....*Hoplandria* Kraatz.
Free corneous extremity of the inner lobe of the maxillæ long, broadly curved inwards from its base, apex acuminate. (Male with a strong, acute, curved process near the outer apical angles of the elytra.)...*Genosema*, new genus.

GENOSEMA, new genus

Maxillæ with the lobes unequal in length, the inner two-thirds the length of the outer which is entirely membranous, thick, about as long as broad, straight, ciliate on apical half; inner lobe with a broad membranous appendage attached to the basal half; free apical corneous part moderately slender, strongly bent inward at its base, moderately arcuate, the extreme apex more attenuate and arcuate.

Maxillary palpi five-jointed; second and third joints very moderately and nearly equally incrassate, subequal in length. Labial palpi four-jointed, first longer and thicker than the second which is much shorter, third more slender, longer, but shorter than the first.

Ligula very long and slender, as long as or slightly longer than the first joint of the labial palpi, deeply divided at apex.

Mentum trapezoidal, apex about one-half the width of the base, very feebly triangularly emarginate, strongly transverse, bilaterally impressed.

Eyes moderate in size; tempora convergent, not conspicuous, two-thirds the diameter of the eyes; infralateral carinæ strong entire; gular sutures widely separated, diverging and slightly arcuate to the base.

Antennæ moderately long and gradually moderately incrassate; first joint thickened; second and third equal in length; third slightly more slender.

Prosternum very short. Intermediate coxæ widely separated; mesosternal projection reaching the middle of the coxæ, contiguous with but not united to the metasternal projection.

Basal tarsal joints of the posterior tarsi equal in length.

Males with a strong, acute process near the outer apical angles of the elytra and a longitudinal carina on the fifth dorsal segment.

Genosema sexualis, new species

Plate XXXIX, Figure 4

Form (♂) moderately broad, (♀) more slender, slightly fusoid, moderately convex. Color testaceo-rufous, thorax and legs more testaceous; head, antennæ except the extreme tip, elytra except the humeri, the fifth abdominal segment and the metepisterna blackish. Integuments very strongly shining. Head very sparsely and indistinctly punctured; thorax and elytra moderately coarsely, subasperately, but not densely punctured; abdomen nearly impunctate except for rows of rather coarse punctures close to the bases of the basal segments. Head about one-fourth wider than long, a little more than one-half the width of the thorax (♂), two-thirds the width of the thorax (♀); eyes moderate in size, tempora two-thirds their length, slightly convergent, not at all prominent. Antennæ longer than the head and thorax; fourth joint very slightly elongate; fifth and sixth as long as wide; seven to ten transverse; ten one-half wider than long (♂), less transverse (♀). Terminal joint oval-conic, acute, longer than the two preceding. Thorax three-fifths wider than long in male (♂), one-third in female (♀), as wide as the elytra at their base but narrower than their apex; apex of the thorax slightly narrower than the base, sides and base strongly rounded, posterior angles nearly obsolete; disk rather strongly convex with a large median impression slightly before the base in the male. Elytra conjointly a little more than one-fourth wider than long in the male (♂), nearly one-half wider than long in female (♀), suture slightly longer than the thorax (♂), as long as the thorax (♀); outer apical angles more strongly produced in the male than in the female. Abdomen slightly narrower than the elytra at base, sides broadly arcuate and narrowed; fifth segment about half as wide as the base (♂), wider (♀). Length, 2.5-3 mm.; width, .7-.8 mm. ♂, ♀. Four specimens.

Male.—Elytra with a strong, acute process near the outer apical angles; the inner sutural angles strongly swollen. First and second abdominal segments with lateral spines, those on the second about one-half as long as those on the first; fifth dorsal segment with a large, acute, median, carinate tooth.

Female.—Unmodified.

Type male, allotype female, and two paratypes, Monticello, eastern arm of Lake Micesoukee, October 8, in cheese traps; (Mutchler).

H. debilis Sharp (Guatemala, Biol. Cen. Amer., I, part 2, p. 224) and *H. pulchra* Kraatz (Louisiana, Georgia, Linn. Ent. Zeits., XI, p. 6) probably belong with the above described species. *H. debilis* is a black species; the third antennal joint is said to be rather shorter than the second and the elytral processes recurved. *H. pulchra* is described as having the thorax more than twice as wide as long, the sides and base slightly rounded; surface densely and finely punctured; elytra one-half longer than the thorax with dense, strong, rugulose punctures; the male with a short lateral spine on the second abdominal segment only.

LOPHOMUCTER, new genus

Maxillæ with the lobes more or less fused and indistinguishable; outer lobe short, membranous, ciliate; inner lobe shorter than the outer, narrowed to a more or less acute apex, straight, inner edge straight with an angulation near the middle, ciliate above the angulation.

Maxillary palpi five-jointed; second joint rather strongly pedunculate and slightly arcuate; third straight, subequal in length to the second, very slightly thicker and evenly, not very strongly incrassate; fourth joint subulate, about two-thirds the length of the third. Labial palpi four-jointed; first joint elongate and thicker; second short; third long but shorter and more slender than the first.

Ligula elongate, linear, about as long as the first joint of the labial palpi; apex blunt, entire.

Mentum trapezoidal, about one-third wider than long; apex two-thirds the width of the base, feebly circularly emarginate, bilaterally impressed.

Mandibles obtusely curved and acuminate at apex; inner edge with an obtuse angulation at middle.

Eyes large, strongly convex; tempora very short, scarcely apparent; infralateral carinae very strong, entire; gular sutures moderately separated at apex, straight and rather strongly divergent to the base.

Antennæ moderate in length, rather strongly incrassate; first joint long and stout, as long as the next three; second and third of equal length.

Prosternum short. Intermediate coxæ widely separated; meso- and metasternal projections solidly united, suture transverse, slightly before the middle of the coxæ.

Tarsi 4-5-jointed; four basal joints of the posterior tarsi of equal length.

Males with the elytra carinate at the humeri and with short processes at the apical, sutural angles.

Lophomucter lævicollis, new species

Plate XXXIX, Figure 6

Form rather broad, moderately convex. Color rufo-testaceous; head and the elytral suture narrowly, blackish; outer antennal joints slightly infusate. Integuments strongly shining, finely, very sparsely and indistinctly punctate throughout. Thorax with four distinct discal punctures. Head nearly one-third wider than long, nearly two-thirds the width of the thorax. Antennæ as long as the head and thorax; second and third joints moderately elongate; fourth joint as long as wide, somewhat rounded; fifth joint nearly one-half wider than long, distinctly wider than the fourth; outer joints slightly wider and more transverse, forming a rather parallel-sided, elongate club; terminal joint short, conical, as long as the preceding two. Thorax one-half wider than long, as wide as the elytra at base, narrower than the elytral apex, strongly rounded on sides and base; apex slightly narrower than the base; hypomera visible from the side. Elytra conjointly one-half wider than long, sides arcuate and divergent, suture four-fifths the length of the thorax; apex not emarginate. Abdomen much narrower than the elytra at base, as wide as or slightly wider at the apical margin of the second segment; fifth segment about two-thirds the width of the base; side margins very broad and flattened above. Length, 3.5 mm.; width, 2.25 mm. ♂. One specimen.

Male.—Clypeus with a strong longitudinal carina. Elytra with a short humeral carina and a rather small, blunt pointed, carinate tooth at the sutural angle. Abdomen with a moderate-sized, rounded tuberosity at the middle of the second segment and a low, carinate tooth on the fifth dorsal segment. (It is possible that some of these modifications may occur in both sexes.)

Female.—Unknown.

Type, Fort Myers, April 26, from a hog's head; (Grossbeck).

This species is one of considerable systematic interest. Although evidently a close ally of *Hoplandria*, the form of the head, the intermesocoxal parts and the smooth, quadripunctate thorax indicate a distinct relationship to the bolitocharid genus *Gyrophæna* and its allies.

TINOTUS Sharp

***Tinotus amplus*, new species**

Form rather stout, fusiform, moderately convex. Color dark rufo-piceous, elytra slightly paler, head and abdomen darker, nearly black, the latter with the apical margins of the segments rather broadly paler, rufo-piceous; sixth segment entirely pale. Surface strongly micro-reticulate; lustre dull; abdomen more shining; punctures on the head rather fine and indistinct and somewhat sparse; those on the thorax and elytra strong, dense and asperate, those on the elytra a little more coarse; punctures of the abdomen rather fine and sparse, not strigose nor imbricate except feebly so on the basal segments but with very faint elongate impressions behind each puncture. Pubescence thick, pale reddish. Head less than a third wider than long, one-half the width of the thorax, evenly convex; eyes moderate in size, not prominent; tempora one-half their diameter. Antennæ as long as the head and thorax, slender; third joint slightly longer than either the first or the second; first cylindrical, thicker; second and third obconic; fourth joint as wide as long; outer joints very slightly incrassate; tenth joint about one-third wider than long; terminal joint obtusely pointed, as long as the preceding two. Infralateral carinæ strong, entire. Thorax two-thirds as wide as long, strongly convex, sides subparallel in basal half, strongly rounded and converging in apical half; base very moderately rounded, posterior angles very obtuse but distinct. Elytra very slightly wider than the thorax, sides parallel, conjointly three-fifths wider than long; suture equal in length to the thorax, outer apical angles slightly retraced with feeble sinuses. Abdomen as wide as the elytra at base, sides almost straight and feebly convergent to the apex of the fifth segment which is three-fourths the width of the base. Length, 2 mm.; width, 1.25 mm. ♂. One specimen.

Male.—Thorax with a large round impression occupying more than the median third of the disk. Fourth dorsal abdominal segment with the apex broadly, arcuately emarginate, the emargination the width of the segment. One specimen.

Female.—Unknown.

Type, Enterprise, October 30, Cassias.

This species differs in antennal structure and the punctuation of the abdomen from those described hitherto.

***Tinotus brunnipes*, new species**

Form slightly robust, subparallel, moderately convex. Color dark brownish-piceous; bases of the abdominal segments more or less blackish, base of the antennæ and the legs paler. Lustre dull; surface micro-reticulate. Punctures of the head fine and indistinct; of the thorax and elytra distinct, rather close and asperate, those on the disk of the thorax distinctly finer. Basal segments of the abdomen imbricate; imbrication obsolete on the fourth and fifth dorsal segments. Head very slightly wider than long, nearly two-thirds the width of the thorax, widest behind the eyes, narrowed anteriorly; eyes moderate in size, very much flattened, slightly longer than the tempora. Antennæ short, as long as the head and thorax; second and third joints elongate, of equal length; fourth and fifth as long as wide; outer joints gradually wider, strongly transverse, nearly twice as wide as long; terminal joint obtusely pointed, as long as the two preceding. Thorax strongly convex, one-half wider than long, sides evenly, arcuately narrowed from base to apex; base rounded, feebly sinuate laterally, posterior angles not distinct. A faint basal impression either side at the scutellum. Elytra (♀) very slightly wider than the thorax; the suture as long as the latter, sides feebly arcuate; apical sinuses feeble. Abdomen as wide as the elytra at base; sides arcuate and slightly narrowed to the apex of the fifth segment which is three-fourths the width of the base. Basal joint of the posterior tarsi equal in length to the next two. Length, 2.5–2.75 mm.; width, .6–.75 mm. ♀. Two specimens.

Type and paratype, labeled "Fla."

This species is distinguishable from the preceding by its narrower thorax, larger head, antennæ with much more transverse outer joints. Both seem to be distinguishable by the feebler abdominal sculpture and the head distinctly wider posteriorly as well as by other characters from those described by Col. Casey.

***Tinotus planulus*, new species**

Form not stout, subparallel, slightly convex. Color dark piceous, nearly uniform; apical margins of the dorsal abdominal segments slightly paler; basal joints of the antennæ not paler; legs pale with a reddish tinge. Lustre very dull; head very indistinctly punctured, more shining; thorax and elytra micro-reticulate, punctures close and asperate, not medially finer on the disk of the thorax. Abdomen strongly imbricate throughout but not at all micro-reticulate. Head sub-orbicular, two-thirds the width of the thorax, about one-fourth wider than long, widest behind the eyes which are moderately large but flat; tempora very little more than one-half the diameter of the eyes. Antennæ as long as the head and thorax; third joint slightly shorter and more slender than the second; fourth as long as wide; fifth distinctly transverse; outer joints gradually strongly incrassate; the ninth and tenth slightly more than twice as wide as long; terminal joint very short, slightly longer than wide, as long as the two preceding. Thorax one-third wider than long, widest a little before the base, sides rather feebly arcuate and narrowed anteriorly; base broadly rounded and feebly sinuate laterally; posterior angles very obtuse, slightly distinct; disk moderately convex, without basal impressions. Elytra at apex very

slightly wider than the thorax, conjointly one-half wider than long, suture distinctly shorter than the thorax; sides subparallel, very feebly arcuate. Abdomen very nearly as wide as the elytra at base, fifth segment nearly four-fifths the width of the base. Basal joint of the posterior tarsi as long as the next two. Length, 1.25-1.5 mm.; width, .4 mm. Twenty-two specimens.

Type and six paratypes, Gainesville, October 1, under cow dung; (Mutchler). Three paratypes labeled "Fla." and one Enterprise, October 12. Other specimens: eight from the type locality; two, Enterprise; two, labelled "Fla."

The specimens at hand are apparently all females. The sixth dorsal segment is just perceptibly emarginate medially.

The species is distinguished by its narrow slightly flatter thorax. It is evidently related to *T. parvicornis* Casey. In that species the thorax is described as three-fourths wider than long.

***Trichiusa ursina*, new species**

Form short and stout, rather parallel. Pubescence long, abundant and conspicuous throughout. Color pale rufo-er'aceous (immature). Head behind the antennæ one-third wider than long, three-fourths the width of the thorax; eyes rather large and convex, distant about their diameters from the base; tempora straight and slightly convergent; front strongly impressed; infralateral carinæ lacking. Antennæ reaching the basal third of the elytra, gradually rather strongly incrassate; second joint stouter and slightly longer than the third, both feebly elongate; fourth as long as wide; the outer joints becoming rapidly more transverse; tenth twice as wide as long; terminal joint as long as the two preceding. Thorax narrower than the elytra at base, widest at middle where it is three-fifths wider than long, sides arcuate and convergent anteriorly, nearly straight and very slightly convergent posteriorly to the obtuse and scarcely distinct posterior angles; disk very convex, with a broad impression before the scutellum. Head and thorax strongly shining, punctuation very fine and indistinct. Elytra conjointly three-fifths wider than long; suture as long as the thorax, sides slightly divergent, humeri well exposed, punctuation consisting of rather fine setæ-bearing punctures only; lustre duller than that of the thorax. Abdomen rather more distinctly but less densely punctate. Length, 1.6 mm.; width, .65 mm. One specimen.

Type, Punta Gorda. November 12, sifting débris on beach of Charlotte Harbor, at high-tide mark; (Leng).

This species is distinguished by its antennal structure, thoracic form and short elytra with simple punctuation. It is probably near to *T. convergens* Casey and *T. monticola* Casey.

***Atheta* Thomson**

***Atheta macrops*, new species**

Form moderately slender, parallel, slightly convex. Color piceo-testaceous. Thorax and basal segments of the abdomen with a reddish tinge; head and segments three and four of the abdomen blackish; outer antennal joints infusate. Surface micro-reticulate; head and abdomen rather strongly shining; thorax and elytra feebly shining. Head nearly impunctate, punctures very fine, sparse and indistinct.

Thorax and elytra rather finely but distinctly and somewhat densely punctate. Basal segments of the abdomen rather densely punctate; fifth segment nearly impunctate. Pubescence on the thorax and elytra rather long. Head one-third wider than long, five-sixths the width of the thorax; eyes very large and prominent; tempora little more than half their diameters, rather strongly convergent, not at all parallel; infralateral carinae strong and entire. Antennae longer than the head and thorax, feebly incrassate; second and third joints elongate, subequal in length; fourth as wide as long; tenth about one-fourth wider than long; terminal joint oval, conic, slightly longer than the preceding two. Thorax one-half wider than long, slightly wider than the elytra; sides subparallel to the apical fourth thence rounded to the apical angles, base broadly rounded, posterior angles very obtuse but somewhat distinct; a rather indistinct median impression and basal fovea. Elytra conjointly one-fourth wider than long, suture scarcely perceptibly longer than the thorax. Abdomen narrower than the elytra at base, sides broadly and evenly arcuate. Basal joints of the posterior tarsi elongate, subequal. Intermediate coxae separated by about one-fifth the width of one of the coxae; the meso- and metasternal projections contiguous at slightly behind the middle of the coxae; apex of the mesosternal projection rounded. Length, 2-2.5 mm.; width, .5-.6 mm. ♂, ♀. Eight specimens.

Male.—Apex of the sixth dorsal abdominal segment with an emargination either side; the rather broad median projection feebly emarginate with its angles broadly rounded; the outer edge of the lateral emarginations prolonged in a short tooth; the lateral emarginations trapezoidal.

Female.—Sixth ventral strongly rounded with its apical margin finely fimbriate.

Type male, labeled "Fla.," allotype, female, Enterprise, November 15. Four paratypes: three, labeled "Fla." one, Monticello, eastern arm of Lake Miconsoukee, October 8, in cheese trap; (Mutchler).

This species resembles *A. coriaria* Kraatz quite closely in color and form. It is more slender and parallel, the thorax less transverse, the head more transverse, the eyes much larger and the outer antennal joints less transverse. The male abdominal modifications are like those of *A. crenuliventris* Bernhauer.

***Atheta aspericauda* Bernhauer.**

Enterprise, October 12. Pensacola, October 14, in fungus; (Mutchler).

***Atheta* (Hillara) *fulviceps*, new species**

Form slender parallel, scarcely convex, moderately shining. Color pale rufo-testaceous, fourth and fifth segments of the abdomen only slightly infusate. Punctures of the thorax and elytra rather coarse and dense, separated by about their diameters. Pubescence rather coarse but not dense. Head as long as wide; eyes rather large, but feebly convex, distant from the base of the head by slightly less than their diameters; tempora evenly, arcuately and feebly convergent; infralateral carinae strong and entire. Antennae as long as the head and thorax, gradually rather strongly incrassate; first joint more than twice as long as long as wide; second about two-thirds the length of the first, third about two-thirds the length of the second, strongly obconic, fourth distinctly transverse, fifth to tenth twice as wide as long,

gradually larger but not perceptibly more transverse. Terminal joint conical, apex rounded, equal in length to the two preceding. Head, thorax and elytra subequal in width. Thorax one-third wider than long, widest in front of the middle, sides evenly but not strongly arcuate, base broadly rounded, posterior angles indistinct. Elytra conjointly as wide as long, suture scarcely longer than the thorax. Abdomen narrower than the elytra at base, slightly wider to the apex of the fifth segment which is slightly longer than the fourth. Three basal dorsal segments strongly transversely impressed. Mesosternal projection long and slender, nearly two-thirds the length of the coxal cavity, apex narrowly rounded and contiguous with the metasternal projection which is narrower and more parallel. The mesosternal projection is margined throughout, but the margin of the metasternal projection stops at about half its length, the remaining apical portion though narrow is in the same plane as the mesosternal projection. Length, 1 mm.; width, .3 mm. One specimen.

Type, labeled "Fla."

Ganglbauer (Kaf. v. Mitteleu., II, part 1, p. 149) separates the subgenera *Microdota* and *Hilara* by the punctuation of the thorax. The punctures on the thorax of a specimen of (*Microdota*) *amicula*, microscopically viewed, are distinctly finer and separated by about twice their diameters. The punctures on the thorax of (*Hilara*) *palleola* are about as coarse as those of (*H.*) *fulviceps* but are separated by about three times their diameters. The species bears some resemblance to the small *Leptusæ* but the intermediate tarsi are certainly five-jointed as proved by a dissection in balsam.

Acrotoma Thomson

Dr. Fenyès (Gen. Ins., Fasc. 173A, pp. 20, 21) gives the type species of this genus as *A. aterrima* Gravenhorst and for *Colpodota*, *C. pygmaea* Erichson. Ganglbauer, however, places both these species in *Colpodota* (Kaf. v. Mitteleu., II, part 1, p. 146). The work of Mulsant and Rey, the original authority on the two genera, is not available. Ganglbauer separates *Acrotoma* and *Colpodota* as follows:

1. Abdomen equally and more or less densely pubescent.

Colpodota Mulsant and Rey.

Abdomen much less densely pubescent on the fourth and fifth dorsal segments.

Acrotoma Mulsant and Rey.

Synopsis of the Species

(*Acrotoma*)

1. Punctures on the thorax and elytra more or less dense; lustre dull.....2.
Punctures very remote and sparse; integuments very highly polished. (*Neda*
Casey).....*lubricans* Casey.
2. Outer antennal joints strongly transverse, one-half wider than long.....3.
Outer antennal joints not or very slightly transverse.....5.

3. Thorax one-half wider than long.....4.
 Thorax one-third wider than long; elytra as long as the thorax.
bakeri Bernhauer.
4. Head extremely finely and sparsely punctate; elytra slightly longer than the
 thorax; size larger, 2-2.3 mm..... *pasadena* Bernhauer
 Head coarsely and rather closely punctate; elytra very slightly shorter than the
 thorax; size smaller, 1.6 mm.....*hebeticornis*, new species.
5. Elytra distinctly longer than the thorax; suture one-third longer.....6.
 Elytra not distinctly longer than the thorax.....9.
6. Head not strongly transverse.....7.
 Head strongly transverse eyes at less than their diameters from the base.
adjuvanus Casey.
7. Thorax narrower than the elytra.....8.
 Thorax as wide as the elytra.....*lividula* Casey.
8. Fifth and sixth segments of the abdomen polished and coarsely punctured.
modesta Melsheimer.
 Fifth and sixth segments of the abdomen very sparsely, feebly, and subasperately
 punctured.....*fusiformis* Casey.
9. Elytra distinctly shorter than the thorax; suture not more than four-fifths its
 length.....10.
 Elytra not distinctly shorter than the thorax.....11.
10. Thorax wider than any part of the elytra; the latter four-fifths the length of
 the thorax.....*shastanica* Casey.
 Thorax as wide as the apex of the elytra; the latter shorter, three-fourths the
 length of the thorax.....*prudens* Casey.
11. Thorax wider than any part of the elytra.....12.
 Thorax as wide as the elytra.....14.
 Thorax distinctly narrower than the elytra.....15.
12. Head distinctly inflated or swollen at base.....13.
 Head not inflated at the base; antennæ slender; form stout..*renoica* Casey.
13. Antennæ more distinctly incrassate, tenth joint distinctly transverse; thorax less
 rounded at base; elytral suture as long as the thorax; form stout.
severa Casey.
 Antennæ less incrassate, tenth joint not transverse; thorax broadly rounded at
 base, basal impression small and obsolescent; elytral suture not quite as
 long as the thorax; form more slender.....*ardelio* Casey.
14. Head transverse; color dark; abdomen not as wide as the elytra.
digesta Casey.
 Head suborbicular, less transverse; color pale; abdomen as wide as the elytra.
malaca Casey.
15. Fourth antennal joint normal, slightly smaller than the fifth.....16.
 Fourth antennal joint very small, one-half as long as the fifth and much nar-
 rower.....*fuscipes* Herr.

16. Thorax not strongly convex.....17.
 Thorax strongly convex.....18.
17. Color darker; thorax broader, nearly one-half wider than long; size larger.
 2-2.3 mm.....*subpygmaea* Bernhauer.
 Color paler; thorax narrower, less than one-third wider than long; size smaller.
 1.6 mm.....*picescens*, new species.
18. Antennæ paler, at least at base; thorax shorter, one-half wider than long...19.
 Antennæ darker; thorax not so short; one-third wider than long, more narrowed anteriorly.....*orbata* Erichson.
19. Thorax less narrowed anteriorly; basal dorsal segments of the abdomen more densely punctured.....*fungi* Gravenhorst.
 Thorax more narrowed anteriorly; basal dorsal segments of the abdomen not more densely punctured.....*clientula* Erichson.

Homalota modesta Melsheimer seems to be rather doubtfully an *Acrotona* and its position in the above table is more or less conjectural.

***Acrotona picescens*, new species**

Form rather slender, distinctly fusoid, feebly convex, moderately shining. Color rather pale piceous, posterior abdominal segments slightly blackish; legs and antennæ not noticeably paler. Micro-reticulation coarse but very indistinct; punctures on head and thorax large, shallow, umbilicate, separated by about their diameters; those on the elytra subasperate, surface slightly rugulose; punctuation of the abdomen fine, sparse and indistinct. Head, thorax and abdomen more shining. Head very moderately transverse, less than one-third wider than long; tempora about two-thirds the length of the eyes, parallel for half their length. Antennæ nearly attaining the middle of the elytra; first joint longer than the second or the third which are of equal length, about twice as long as wide; fourth and fifth joints as wide as long; outer joints gradually slightly wider; tenth joint slightly transverse; terminal joint oval, conic, slightly longer than the two preceding. Infra-lateral carinae strong, entire. Thorax less than one-third wider than long, moderately, evenly and arcuately narrowed from base to apex; base broadly rounded, not perceptibly sinuate laterally, posterior angles not distinct. Elytra as wide as the thorax at base, slightly wider at apex; suture very slightly shorter. Abdomen narrower than the elytra at base, sides evenly and arcuately narrowed. Mesosternal projection long, narrow, reaching the posterior third of the coxæ, narrowly rounded at apex, almost contiguous with the metasternal projection. Coxæ narrowly separated. Basal joints of the posterior tarsi subequal, first joint very slightly longer. No sexual differences observable. Length, 1.5-1.6 mm.; width, .35-.45 mm. Nine specimens.

Type, Enterprise, December 15. Eight paratypes: 4, Enterprise, October 17, November 1 and 22, December, 12; 2 labeled, "Fla."; 1 Punta Gorda, November 11, sifting debris on shore at mouth of Peace River; (Leng).

Acrotona hebeticornis, new species

Form slightly stout, slightly convex, fusoid. Color piceous brown; elytra paler more testaceous; abdomen black, basal segments more or less brownish; basal joints of the antennæ and the legs rather pale testaceous. Micro-reticulation and punctuation as in the preceding. Head as in the preceding. Antennæ shorter and slightly more slender, as long as the head and thorax; fourth joint as wide as long; fifth joint very slightly transverse; outer joints very gradually larger and more transverse; tenth joint one-half wider than long; terminal joint very slightly longer than the two preceding, very obtusely rounded at apex, feebly conic. Infra-lateral carinæ strong, entire. Thorax nearly one-half wider than long, apex narrower than the base, sides evenly and rather feebly arcuate, base broadly rounded, slightly flattened laterally, posterior angles scarcely evident; disk without impressions. Elytra as wide as the thorax at base, slightly wider at apex, very slightly shorter than the thorax on the suture. Abdomen narrower than the elytra at base. Basal joint of the hind tarsi elongate, a little longer than the second. Intermesocoxal parts as in the preceding. No sexual differences observable. Length, 1.75 mm.; width, 4 mm. Three specimens.

Type, Enterprise, December 15. Two paratypes: 1 Enterprise, November 19; 1 Punta Gorda, November 11, sifting debris on shore at mouth of Peace River; (Leng).

This species resembles the preceding very closely. It may be distinguished by the antennal structure and distinctly more transverse thorax.

Gnypeta floridana Casey.

Enterprise, December 12.

Aleodorus partitus (LeConte).

Enterprise, October 12. Titusville.

Group **FALAGRIÆ**

Synopsis of the Genera

1. Dorsal segments of the abdomen transversely impressed.....2.
Dorsal segments of the abdomen not transversely impressed.. *Demera* Fauvel.
2. Posterior thoracic angles not dentiform.....3.
Posterior thoracic angles produced, dentiform; form broad, fusoid.
Dorylonilla Wasmann.
3. Prosternum not carinate.....4.
Prosternum carinate..... *Ecilonilla* Wasmann.
4. Intermediate coxæ not contiguous.....5.
Intermediate coxæ contiguous..... *Drepanopora* Bernhauer.
5. Mesosternum not carinate.....6.
Mesosternum carinate..... *Lophagria* Casey.
6. Metasternum not elevated nor subcarinate.....7.
Metasternum elevated anteriorly, subcarinate..... *Amaurodera* Fauvel.
7. Thoracic hypomera delimited from the flanks of the pronotum by a carinate edge or by a difference in the sculpture.....8.

Thoracic hypomera not delimited from the flanks of the pronotum.

Cardiola Mulsant and Rey.

8. Mesosternum on the same plane with the metasternum.....9.
Mesosternum elevated, on a different plane from the metasternum.
Chitalia Sharp.
9. Flanks of the pronotum separable from the hypomera by differences of sculpture only.....10.
Flanks of the pronotum with a carinate edge.....12.
10. Head with the posterior angles more rounded, sides less distinct; front not impressed. Form convex.....11.
Head subquadrate with the sides more parallel; front longitudinally impressed; form distinctly flattened.....*Borboropora* Kraatz.
11. Mesos'ernal projection long, reaching the middle of the coxæ and separated from the metas'ernal projection. Thorax less s'trongly narrowed pos'eriorly and less s'trongly sulcate. Head not transverse.....*Lissagria* Casey.
Mesos'ernal projection short, extending to anterior third of the coxæ, fitting over the me'as'ernal projection. Thorax more s'trongly narrowed posteriorly, deeply sulcate. Head strongly transverse and truncate at base.
Omoschema, new genus.
12. Antecoxal part of the prosternum moderate in size.....13.
Antecoxal part of the prosternum very large.....*Stenagria* Sharp.
13. Mesosternal projection reaching the middle of the coxæ.....14.
Mesosternal projection but slightly produced between the coxæ.
Santhota Sharp.
14. Head not broader behind, more or less rounded; thorax convex, moderately to strongly narrowed pos'eriorly.....15.
Head broader behind the eyes; thorax flatter, feebly narrowed pos'eriorly.
Eccoptoglossa Luze.
15. Corneous plates under the anterior coxæ united on the median line.....16.
Corneous plates under the anterior coxæ very small and rudimentary, not united.....*Falagriota* Casey.
16. Thoracic hypomera shorter and broader.....17.
Thoracic hypomera long and narrow.....*Lorinota* Casey.
17. Scutellum carinate.....*Falagria* Mannerheim.
Scutellum not carinate.....*Anaulacaspis* Ganglbauer.

Omoschema, new genus

Labial palpi elongate, slender, three-join'ed, joints scarcely differing in length or thickness. Maxillary palpi rather long and slender, third joint a little longer than the second and thicker but not strongly inflated; terminal joint very slender, about half as long as the preceding.

Mentum trapezoidal, strongly transverse. Gular sutures well separated, very slightly divergent posteriorly.

Head truncate at base, strongly transverse; eyes large, distant from the base; antennæ long, distinctly incrassate, second joint longer than the third. Neck very narrow.

Thorax moderately convergent posteriorly, disk strongly sulcate, marginal carinæ wanting.

Prosternum very short before the coxæ, broadly dilated behind and under them, completely filling the post-coxal opening.

Intermediate coxæ well separated. The mesosternal projection extending only to the anterior third of the coxal length; apex parallel, rounded, fitting over the end of the long metasternal projection; coxal cavities without a beaded edge posteriorly.

Abdomen ventricose, wider than any other part of the body.

Posterior tarsi elongate, slender, the first joint as long as the next three.

Scutellum coarsely, variolately punctate.

Omoschema laticeps, new species

Form elongate, ventricose, rather convex. Color dark brownish-testaceous; legs somewhat paler, terminal joint of the antennæ very pale, basal joint slightly so. Head and thorax finely and somewhat densely punctured; abdomen more densely punctate on the sides of the segments, nearly smooth medially. Pubescence throughout fine, rather long, dark and inconspicuous. Head behind the antennæ nearly twice as wide as long; eyes rather large, distant from the base their own diameters, base truncate, sides parallel, nearly straight, posterior angles moderately rounded, neck about one-fourth the width of the head. Antennæ long, rather stout distally, reaching the middle of the elytra; second and third joints strongly elongate; four to seven distinctly elongate; nine and ten as long as wide; terminal joint large, oval-conic, slightly longer than the preceding two. Thorax scarcely perceptibly narrower than the head, about three-fourths the width of the elytra, widest at apical fourth where it is very nearly as wide as long, sides strongly rounded and convergent anteriorly, very moderately convergent and broadly sinuate posteriorly, posterior angles very obtuse but distinct. Thoracic disk very convex with a strong, deeply impressed median sulcus reaching the apex and broadening to a deep fovea at the base. Abdomen widest at the apex of the fourth segment.

Length, 2.5 mm.; width, .5 mm. One specimen.

Type, Titusville, November 8, sifting leaves in forest; (Lutz).

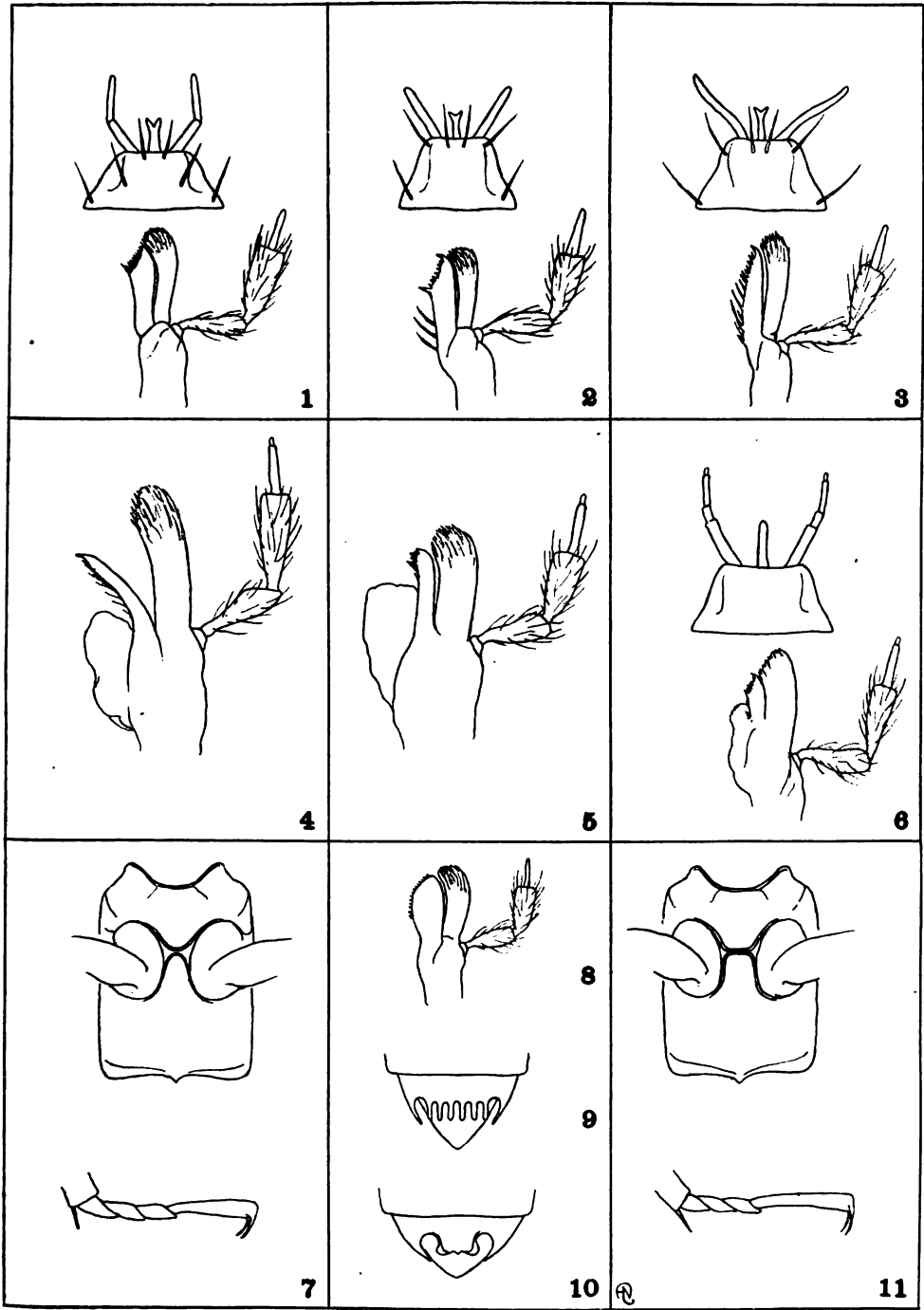
The elytra are unfortunately lacking in the single specimen at hand but the structural features are sufficient to distinguish the species.

***Baryodma nitidicollis* Casey.**

Enterprise, November 20.

PLATE XXXIX

- Fig. 1. *Schistacme obtusa* (labium, maxilla).
- Fig. 2. *Elachistarthron ambiguum* (labium, maxilla).
- Fig. 3. *Orthodiatelus innotabilis* (labium, maxilla).
- Fig. 4. *Genosema sexualis* (maxilla).
- Fig. 5. *Hoplandria lateralis* Melsheimer (maxilla).
- Fig. 6. *Lophomucter laevicollis* (labium, maxilla).
- Fig. 7. *Elachistarthron ambiguum* (intermesocoxal parts, intermediate tarsus).
- Fig. 8. *Eumicrota anomala* (maxilla).
- Fig. 9. *Orthodiatelus innotabilis* (sixth dorsal abdominal segment, ♂).
- Fig. 10. *Silusida tenuicornis* (sixth dorsal abdominal segment, ♂).
- Fig. 11. *Orthodiatelus innotabilis* (intermesocoxal parts, intermediate tarsus).



INDEX TO VOLUME XLII

New taxonomic names are printed in **heavy-faced type**, also the main reference in a series of references.

- ABROCOMA**, 475.
Acanthopus, 595.
Acanthostoma, 223, 225.
Acraspis compressa, 353.
 compressum, 353.
 compressus, 353.
 quercus-erinacei, 355.
Acromyrmex jamaicensis maritima, 428.
Acrotona, 727.
 adjuvanus, 728.
 ardelio, 728.
 aterrima, 727.
 bakeri, 728.
 clientula, 729.
 digesta, 728.
 fungi, 729.
 fuscipes, 728.
 fusiformis, 728.
 hebeticornis, 728, **730**.
 lividula, 728.
 lubricans, 727.
 malaca, 728.
 modesta, 728.
 orbata, 729.
 pasadenæ, 728.
 picescens, 729.
 prudens, 728.
 renoica, 728.
 severa, 728.
 shastanica, 728.
Actinodon, 225.
Actobius cinerascens, 705.
 pareus, 705.
Acylophorus pronus, 706.
Adapidæ, 201.
Adapinæ, 201.
Adapis, 109, 201–209.
Adinotherium, 178.
Æluropus, 151.
Ælurus, 148–151, 153, 213.
Æthalion reticulatum, 465.
Ætosauridæ, 126.
Ætosaurus, 128.
Agathidium, 80.

Agenia, 576.
Alcis haydenata, 489.
Alectis, 286.
 alexandrinus, 291, 292.
 ciliaris, **286**, 287, 290–292.
 crinitus, 286.
 fasciatus, 286.
 gallus, 286.
 hopkinsi, 292.
 indicus, **286**, 288, 290–292.
Aleochara dubia, 707.
Aleodorus partitus, 730.
Alligator, 107, 124, 125, 228.
Alligatorium, 125.
Alouatta, 210, 211.
Alterodon, 474. See *Halterodon*.
 major, 474, 475.
Amaurodera, 730.
Amblotherium, 236.
Amblyrhiza, 471.
 inundata, 470.
Amblystoma, 117.
Amblystomidæ, 117.
Amegilla, 569, **670**, 572, 575, 576, 580, 581.
Amenusa, 717.
Ameristus, 394.
Amia, 112, 219, 220.
Amiidæ, 112.
Ammonites biplex, 672.
 canaliculatus, 681–683, 689.
 plicatilis, 670–673.
 solaris, 673.
 virgulatus, 689.
Amphibamidæ, 226.
Amphibamus, 226.
Amphibolips, 358, 361, 368, 369, 397, 400.
 citriformis, 365.
 coelebs, 365.
 confluens, 325, 356, 382.
 ilicifoliæ, 365.
Amphiproviverra, 107, 139, 141, 145, 215.
Amphitherium, 236, 239.
Amynodon, 279.

- intermedius*, 280.
Amynodontidae, 197.
Anaptomorphus, 204, 206.
Anaulacaspis, 731.
Ancæna, 14, 17, 28, 51, **71**, 81-83, 86.
 infuscata, 7, 58, **71**, 74, 86.
 limbata, 7, 71, 74, 86.
Ancodon, 190, 191.
Ancyloscelis, 569, 592.
Andrena, 580.
Andricus, 294, 320, 360, 361, 370, 371, 400.
 callidoma callidoma, 381.
 callidoma cirratus, 380.
 cellularius, 371.
 championi, 305.
 cicatricula, 302.
 cicatriculus, 302, 303.
 collaris collaris, 379.
 collaris curvator, 379.
 concolorans, 302.
 corticis corticis, 380.
 corticis gemmatus, 380.
 dasydactyli, 371.
 davisi, 295.
 dugesi, 306.
 durangensis, 306.
 foecundatrix gemmæ, 380.
 foecundatrix pilosus, 380.
 fulvicollis, 353.
 fulvicollis bicolens, **354**, 381.
 fulvicollis erinacei, **355**, 356, 381.
 furnaceus, **304**, 306.
 futilis, 341.
 futilis futilis, **341-343**, 379.
 futilis radiceicola, 343, 379.
 incomptus, 306.
 inflator globuli, 380.
 inflator inflator, 380.
 malpighii malpighii, 381.
 malpighii nudus, 381.
 marmoreus, 307.
 mexicanus, 308.
 montezumus, 306.
 noduli radicis, 378.
 notha, 349, 351.
 operatola, 347.
 operator, **345**, 347, 372.
 operator operatola, **347-349**, 380.
 operator operator, 345, 380.
 osten-sackeni, 365.
 palustris, **348**, 349, 351.
 palustris compressus, 353, 381.
 palustris palustris, **349**, 350-353, 381.
 papillata, 341.
 papillatus, 341, 342.
 pellucidus, **309**, 310, 384.
 peredurus, 305, **310**.
 pomiformis, 383.
 punctatus, 295.
 pusulatoides, 350, 351.
 quercifoliae, 350.
 radiceicola, 343.
 radicis, 343.
 radicis trilineatus, 378.
 ramuli autumnalis, 378.
 ramuli ramuli, 378.
 seminationis, 369.
 singularis, 365.
 tecturnarum, **312**, 384.
 testaceipes sieboldi, 380.
 testaceipes testaceipes, 380.
Anthedon, 593, 600.
Anthemoessa, 569, 570.
Anthony, H. E., New Mammals from Jamaica, 469-475.
Anthophora, 553, 554, 561, 565, 569, **570-583**, 588-593, 615, 624.
Anthophoridae, 549.
Anthophorinae, 569.
Anthophoroides, 581, 582.
Anthophorula, 549, **564-567**, 582.
Anthracotheriidae, 190, 191.
Antillamyrmex, 407, **408**, 423, 424.
Antistrophus, 387.
Apateonidae, 114, 226.
Apathus, 502-505, 509, 514, 517, 539-543.
Aphænogaster relicta, 407.
 relicta epinotalis, 407.
Apheloglossa, 711.
Apidae, 492.
Apis, **492**, 493, 495, 502-504, 520-523, 539, 544-547, 554, 570, 615.
Apterodon, 148, 151.
Aræoscelidae, 130.
Aræoscelis, 107, 129, 130, 227.

- Archæohippus*, 273.
 ultimus, 270, 271.
Archæolemur, 109, 203, 205.
Archæolemurinae, 203.
Archæopteryx, 103.
Archegosauridæ, 116, 223, 225.
Archegosaurus, 116, 225.
Arctocyonidæ, 238.
Arctomys, 172, 173, 242.
Arsinoitheriidæ, 182.
Arsinoitherium, 182, 184, 244.
Asclepiadiphila, 387.
Astenus binotatus, 703.
 fusciceps, 704.
 spectrum, 704.
Astrapotherium, 177, 278, 279.
Ataxioceras, 670, 689.
 virgulatus, 689, 690.
Atelerix, 162.
Atelopus festæ, 446.
Atheta, 725.
 aspericauda, 726.
 coriaria, 718, 726.
 fulviceps, 726.
 macrops, 725.
 testaceipes, 717.
Atililemur, 206.
Atta floricola, 406.
 geminata, 427.
 insularis, 428, 429.
 maritima, 428.
Aulacidea, 293, 357c, 358, 361, 367-369,
 371, 375, 382, 383-~~385~~, 388-396,
 400, 401.
 abditæ, **296**, 386, 388.
 annulata, **298**, 371, 384, 386.
 bicolor, 297, 371, 386, 388.
 hieracii, 385, 387.
 nabali, 371, 386.
 podagræ, 297, 371, 386.
 tumida, 298, 362, 371, 385, 386.
Aulax, 287.
 glechomæ, 326.
 glechomatis, 326.
 similis, 326, 327.
Avahis, 205.
Aylax, 357c, 358, 361, 368, 369, 385-**387**,
 390-400, 401.
 gillettei, 297.
 glechomæ **326-328**, 388, 389.
 hieracii, 363.
 kernei, 388, 389.
 latreillei, 388, 389.
 papaveris, 389.
 pisum, 362, 385, 388, 389.
 rhœadis, 389.
 rufus, 297, 388.
 salviæ, 388.
 stephanotidis, 388.
 taraxaci, 328.

BALÆNA, 160.
Balænoptera, 159, 160.
Balænopteridæ, 159.
Baryodma nitidicollis, 732.
Basilarehia archippus lanthanis, 449.
 floridensis halli, 449.
Bassariscus, 150, 151.
Belonuchus formosus, 706.
Beluga, 160.
Berosus, 10, 14, 42, **47**, 79-81, 83, 85, 87.
 æriceps, 47, 51.
 peregrinus, 7, 47, **48**, 51, 81.
 signaticollis, 7, 47.
 spinosus, 7, 47, 49.
 striatus, 7, 47, 51.
Bettongia, 145.
Biorhiza, 294.
 aptera, 373.
 forticornis, 374, 382.
 fulvicollis, 355.
 terminalis, 373, 378.
Bledius agonus, 695.
 amatus, 695.
 analis, 697.
 arizonensis, 695.
 assimilis, 697.
 basalis, 698.
 canaliculatus, 697, **698**.
 consimilis, 695.
 cordatus, 698.
 cuspidatus, 696.
 deceptivus, 697.
 dimidiatus, 698.
 episcopalis, 696.
 eximius, 696.

- fenyési, 695.
flavipennis, 695.
foraminosus, 697.
fumatus, 697.
furtivus, 695.
gradatus, 696.
gravidus, 697.
ineptus, 695.
lectus, 696.
monstratus, 695.
nigriceps, 695, **696**.
nitidiceps, 697.
nitidicollis, 697.
opacifrons, 697.
philadelphicus, 697.
piceus, 697.
politus, 696.
punctatissimus, 698.
regularis, 697.
relictus, 697.
rotundicollis, 697.
rubiginosus, 697.
semiferrugineus, 697.
specularis, 697.
strenuus, 695.
tallaci, 697.
tenius, 696.
turgidus, 696.
Blepharis indicus, 285.
 major, 285, 288.
 sutor, 285.
Boa, 107, 130, 228.
Boidæ, 130.
Boletobius pygmæus, 707.
Bolitochara, 713.
Bolosaurus, 230.
Bombias, **502**, 508, 512, 517–519, 525,
 526, 529–532, 538, 539.
Bombidæ, 502.
Bombomelecta, 574.
Bombus, 492, **502–543**.
Borboropora, 731.
Borhyæna, 107, 141.
Borhyænidæ, 139, 141.
Bothriceps, 115, 225.
Brachyceratops, 127.
Brachymyrmex heeri obscurior, **431**.
Brachyopidæ, 115, 223, 225.
Bradypodidæ, 167.
Bradypus, 167.
Branchiosauridæ, 114, 226.
Branchiosaurus, 222, 223, **226**.
 amblystoma, 114.
Bremus, **502**, 504, 507, 511, 520, 529, 539,
 545, 547.
Broiliellus, 115, 225.
Brontotheriidæ, 197.
Bryoporus rufescens, 706.
Bufo coniferus, 446.
 ornatus, 118.
 rostratus, 445.
CACAIAO, 210.
Cænolestes, 144.
Cænopus, 195, 196.
Cafius bistriatus, 705.
Calamoichthys, 101.
Callirhytis, 294, 320, **343**, 400.
 cicatricula, 302.
 clavula, 344, 345.
 furnessæ, 382.
 futilis, 341.
 notha, 349.
 operatola, 325, 347.
 operator, 325, 345, 347.
 palustris, 349.
 papillata, 342.
 papillatus, 341.
 pusulatoides, 350.
 quercus-notha, 350.
 quercus-operator, 346.
 quercus-palustris, 350.
 quercus-papillata, 342.
 radicis, 343.
Callizzia certiorata, 490.
Caloderina, 713.
Calyptapis, 539.
Camelidæ, 187, 193.
Camelus, 193.
Camponotinæ, 431.
Camponotus culmicola hawesii, 439.
 gilviventris, 435.
 gundlachi, 438.
 maculatus lucayanus, 435.
 planatus, 435.
 santosi, 435.

- sphæralis, 403.
 sphæricus, 403, 436.
 sphæricus **cardini**, 438.
 sphæricus sphæralis, 438.
 Camptosauridæ, 126.
 Camptosaurus, 107, 125-127.
 Canidæ, 103, 149, 151.
 Canis, 153.
 Capitosaurus, 225.
 Capromys, 472.
 Captorhinidæ, 102, 121, 227.
 Captorhinus, 227, 228.
 Caranginæ, 291.
 Carangoides, 291.
 Caranx alexandrinus, 289, 291.
 declivis, 480.
 gallus, 288, 292.
 semispinosus, 479.
 symmetricus, 480.
 trachurus japonicus, 479.
 trachurus mediterranea, 479.
 Cardiocondyla emeryi, 406.
 Cardiola, 731.
 Casea, 230.
 Caseidæ, 102.
 Castor, 172, 173, 242.
 Castoridæ, 173.
 Casuarius, 107, 130.
 Catarrhinæ, 210-212.
 Catopyrha, 487.
 Caviidæ, 173.
 Cebidæ, 210.
 Cemolobus, 593, 625.
 Centetes, 164, 165, 208.
 Centetidæ, 164, 165.
 Centrinæ, 549.
 Centris, 504, 544-548, **549-563**, 568-571,
 574, 581, 624, 625.
 Centrolene, 441-445.
 geckoideum, 441.
Centrolenella, 441-445.
 antioquiensis, 441-444, 445.
 buckleyi, 442, 445.
 Cephalopus maxwelli, 270.
 pygmæa, 270.
 Ceratopsidæ, 126.
 Ceratotherium, 279.
 simum, 194, 281.
 Cerecoleptes, 151.
 Cereyon, 15, 77, 81-83, 87, 88.
 ocellatus, 24.
 Ceroptres, 302, 358.
 cicatriculus, 303.
 Cervidæ, 187.
 Cervulus, 187, 275.
 Cetotherium, 160.
 Chætarthria, 14, 42, **51**, 81, 83.
 atra, 7, 51.
 Chalcididæ, 357b.
 Chalepogenus, **562**, 568, 569.
 Chalicotheriidæ, 195.
 Champsoosaurus, 129, 233.
 Chasmogenus, 65.
 Chelone, 107, 122, 230.
 Chelonidæ, 122.
 Chelydosaurus, 222, 223, 225.
 Chilaspis nitida löwi.
 nitida nitida, 378.
 Chinchilla, 471.
 Chiroleptes, 443.
 Chiromyidæ, 203.
 Chiromys, 110, 203, 205.
 Chironectes, 139.
 Chironomidæ, 69.
 Chitalia, 731.
 Chloraspilates bicoloraria arizonaria, 486.
 Chlorochlamys masonaria, 484.
 Choleva, 80.
 Chriacus, 238.
 Chrysothrix, 210.
 Citula, 291.
 Clænodon, 238.
 Cleora, 488, 489.
 obliquaria, 488.
Clidomys, **469**, 471-474.
 osborni, **469-474**.
 parvus, 471, **472**, 474.
 Clisodon, 574, 576, 580, **582**, 583.
 Cnemidium, 545.
 Cochleosaurus, 225.
 Cockerell, T. D. A., Some Neotropical
 Meliponid Bees, 459-468. See
 also Lutz and Cockerell.
 Cœlostoma, 77, 81, 87.
 Cœnocalpe aurata, 486.
 Cœnocharis macedunnoughi, 488.

- ochrofuscara, 488.
 Colobopsis, 403, 436-439.
 Colonoceros agrestis, 195.
 Colpodota pygmæa, 727.
 Comstock, W. P., see Watson and Comstock.
 Conoryctidæ, 166, 167.
 Conosoma basalis, 706.
 ornatum, 706.
 scriptus, 706.
 Conotelus, 465.
 Corythosaurus, 127, 128.
 Crematogaster sanguinea, 425.
 sanguinea **atavista**, 425.
 sanguinea **sotolongoi**, 425.
 sanguinea **torrei**, 425.
 victima **cubaensis**, 425.
 victima **steinheili**, 426.
 Creniphilus, 71.
 Creophilus maxillosus villosus, 706.
 Creotarsus, 243.
 Cricetidæ, 173.
 Cricotus, 101.
 Crocodylidæ, 228.
Croesomyrmex, 406, 421, 422.
 Crossarchus, 152, 153.
 Cryniphilus, 71, 74.
 Cryptobranchus, 224.
 Cryptocerus, 430.
 hæmorrhoidalis, 430.
 varians, 430.
 Cryptoprocta, 153, 156.
 Cryptorhopalum, 465.
 Cyanocentris, 550-562.
 Cyclopes, 169-171.
 Cyclotosaurus, 116, 225.
 Cyclura, 107, 130.
 Cyloma, 81, 82.
 Cymatophora minuta, 487.
 Cymbiodyta, 14, 22, 42, **56**, 76, 80-83, 86, 88.
 blanchardi, 8, 56-58, **61**.
 fimbriata, 8, 10, 56, **57-59**, 61, 65.
 lacustris, 56.
 rotunda, 56.
 Cynipidæ, 293-317, 319-357, 357a-c, 358-402.
 Cynips, 294, 320, 358, 368, 397, 400.
 batatus, 333.
 cicatricula, 302.
 concolorans, 302.
 divisa divisa, 379.
 divisa verrucosus, 379.
 erinacei, 354.
 folii folii, 379.
 folii taschenbergi, 379.
 fulvicollis, 355.
 futilis, 341.
 futilis, 341.
 glechomæ, 326.
 guatemalensis, 308.
 longiventris longiventris, 379.
 longiventris similis, 379.
 megaptera megaptera, 381.
 megaptera renum, 381.
 noxiosa, 336.
 operator, 325, 345.
 pallida, 373, 374.
 pallida aptera, 378.
 pallida pallida, 378.
 papillata, 341.
 quercus-aquaticæ, 350.
 quercus-batatus, 333.
 quercus-erinacei, 355.
 quercus-futilis, 341.
 quercus-notha, 349.
 quercus-operatola 325, 347.
 quercus-operator, 324, 345.
 quercus-palustris, 349.
 quercus-papillata, 341.
 quercus-podagræ, 295.
 quercus-punctata, 295.
 rosæ, 328.
 scutellaris, 379.
 sulcatus, 398.
 tuberculosa, 294.
 Cynodictis, 151.
 Cynognathus, 133, 134, 228, 232.
 Cynosuchus, 134, 232.
 Cystophora, 158.
 DACTYLIOCERAS, 670.
 Danaus berenice, 449.
 Dapedius, 220.
 Daphænus, 149, 151.
 Dascyllidæ, 58.

- Dasiapis*, 583, 609.
Dasyceps, 223, 225.
Dasycoymbia gracilata, 484.
Dasypodidæ, 108, 167.
Dasypus, 167.
Dasyuridæ, 108, 142, 143.
Dasyurinæ, 142.
Dasyurus, 142, 143, 168.
Daubentonina, 203.
Dawsonia, 223, 226.
Deinopsis myllænoidea, 707.
Delphinidæ, 160.
Deltatherium, 146, 148, 208, 215.
Demera, 730.
Dendrepeton, 225.
Dendroctonus, 12.
Dendrohyrax, 109, 184, 185.
Desmotetrapedia, 562.
Diadasia, 569, 583, **584**–587, 592, 595–602, 608, 613, 614.
Diadasiella, 562, 564, 587.
Diadectes 121, 227, 228, 230.
Diadectidæ, 101, 121, 227.
Diademodon, 232.
Diadiaphorus, 109, 175, 176.
Diastrophus, 293, 358–363, 368–371, 375, 383, 390, 391, 399–401.
 cuscutæformis, 390.
 fragariæ, 300, 389.
 fusiformans, 300.
 glechomæ, 326.
 kincaidi, 371.
 nebulosus, 370, 371.
 rubi, 389, 391.
 similis, 326.
 siminis, 327.
 tumefactus, 299.
Diceratosaurus, 226.
Dichobune, 108, 187.
Dichobunidæ, 186, 187, 243.
Dichorda phoenix, 484.
Dicotyles, 267.
 pecari, 191.
Dicotylidæ, 193.
Dicynodon, 131, 132.
Dicynodontidæ, 132.
Didelphis, 108, 139, 130, 145.
Didelphyidæ, 140.
Didymictis, 239.
Diestota, 711, 717.
 laticornis, 717.
 mayeti, 717.
Dimetrodon, 123, 230.
Dinoceras, 181.
Diochus schaumii, 704.
Dipedia, 587, 592.
Diplocaulidæ, 155, 226.
Diplocaulus, 115, 226.
Diplocynodon, 125.
Diplolepis bedeguaris, 328.
 bedeguaris fungosæ, 328.
 glechomæ, 326.
 rosæ, 328.
Discosaurus, 225.
Disholcaspis, 293, 308, 310, 357c, 358, 361, 368–371, 383, **397**–401.
 arizonica, 398.
 brevipennata, 398.
 centricola, 398.
 cinerea, 365.
 cinerosa, 316, 317.
 douglasi, 398.
 ***fungiformis*, 312, 397.**
 globulus, 399.
 heynei, 316.
 maculipennis, 398.
 ***plumbella*, 314.**
 ***pruniformis*, 315.**
 truckeensis, 398.
 ***unicolor*, 316, 365.**
 weldi, 398.
Dissorhophidæ, 115, 223, 225.
Ditropalia, 713.
Dolichoderinæ, 431.
Dolichosoma, 226.
Dolichostrophus, 394.
Dorcatherium, 187.
Dorylonilla, 730.
Dorymyrmex pyramicus, 431.
 pyramicus niger, 431.
Drepanopora, 730.
Dromæidæ, 130.
Dromocyon, 148.
Dryophanta, 294, 307, 315, 398.
 aquaticæ, 351.
 bella, 310.

- centricola, 310, 398.
 disticha, 369.
 douglasi, 398.
 dugesi, 310.
 erinacei, 354.
 laurifoliae, 351.
 liberæcellulae, 350, 351.
 notha, 349.
 nubila, 310.
 palustris, 349.
 papula, 342.
 rubrae, 310.
 Dysstroma, 484.
 Dytiscidae, 10, 58.
- ECCOPTOGLOSSA, 731.
 Echidna, 139.
 Echidnidae, 139.
 Echinops, 164.
 Ecitonilla, 730.
 Ectocion, 245.
 Ectoconus, 180, 244.
 Edaphosauridae, 102, 122, 227.
 Edaphosaurus, 230.
 Eidolon, 200.
Elachistarthron, 714, **715**, 717.
 ambiguum, **715**, 718.
Elachistarthronini, 714.
 Elasmodontomys, 471.
 obliquus, 470.
 Elephantidae, 183.
 Elephantulus, 198.
 Elephas, 109, 183, 244.
 Eleutherodactylus martinicensis, 441.
 Ellipsoglossa, 119.
 Elopidae, 112.
 Elops, 220.
 Elotheriidae, 190.
 Emeryella, 407.
 Emphor, **587**, 588, 599, 608.
 Emphoropsis, 571-576, **588**-593.
 Enochrus, 65.
 Entechnia, 574, 580, **591**-593, 605, 613.
 Entelodon, 190.
 Entelodontidae, 190, 193.
 Eodelphis, 139.
 Eohippus, 195, 248.
 Eomoropus, 195.
- Eoserpeton, 226.
 Eosiren, 184.
 Epanorthidae, 140.
 Epeicharis, 562, **568**, 569.
 Epicharis, 550, 553, 557, 561, **562**-564.
 Epicharoides, 557, **563**, 564.
 Epimelissodes, 593, **595**, 598.
 Epimetopus, 14, 42, 51, 81, 83.
 Epiplatymetra lentifluata, 490.
 Epiplemidæ, 483, 490.
 Epistylus, 11.
 Epitritus emmæ, 341.
 Equidae, 109, 195, 265, 266, 282.
 Equus, 269, 272, 274-276.
 Erchomus lævis, 706.
 ventriculus, 706.
 Erignathus, 158.
 Erinaceidae, 109, 162, 240.
 Erinaceus, 162, 163, 208, 216.
 Erpetosaurus, 226.
 Eryopidae, 116.
 Eryops, 101, 116, 225.
 Erythrosuchidae, 102.
 Eschatocerus, 357*b*.
 Esthonyx, 103.
 Eubothrus, 387.
 Eucera, 583-587, 591-594, 597, 604, 612, 615, 623, 624.
 Eucerinae, 549, 593.
 Eucharis, 563, 564.
 Euchlæna lutsi, 483, **489**.
 Eudiestota, 711.
 Eufriesia, 544.
 Euglossa, **544**-549.
 Euglossidae, 544.
 Eugnathus, 221.
 Eulæma, **544**-549.
 Eulema, 544-548.
 Eumetopias, 109, 157.
 Eumicrota **anomala**, 718.
 corruscula, 718.
 insolita, 719.
 Eumorpha, **544**, 545, 549.
 Euparkeria, 107, 123-128, 228.
 Eupithecia flavigutta, 486.
 subcolorata, 486.
 Euponera stigma, 404.
 Euprotogonia, 245.

- Eurhinodelphis, 160.
 Eurytomidæ, 301.
 Eusipalia, 711.
 Eusthenopteron, 219.
 Eusynhalonia, 594, 615.
 Euthyglossa, 594.
 Exaleochara, 720.
 Exomalopsis, 549, 562, **564**–568, 574,
 587, 611, 612, 627.

 FALAGRIA, 731.
 Falagriæ, 730.
 Falagriota, 731.
 Felidæ, 103, 156.
 Fernaldia fimetaria, 486.
 partitaria, 486.
 Fiber, 172.
 Figitidæ, 357*b*, 358, 359.
 Fiorentinia, 568.
 Fioriella marianii marianii, 378.
 marianii meunieri, 378.
 Florilegus, **594**, 600, 603, 605, 609, 620.
 Formica simillima, 406.

 GALAGINÆ, 204, 205.
 Galago, 109, 204, 205.
 Galeopithecidae, 198.
 Galeopithecus, 198, 200, 215.
 Galesauridæ, 133.
 Gallichthys, 286.
 ægyptiacus, 285, 289, 291.
 chevola, 285.
 ciliaris, 285.
 crinitus, 285.
 gallus, 285.
 major, 285, 288.
 Gallus alexandrinus, 289, 291.
 Gastrolobium bicolor, 701.
 Gastrophæna, 713.
 Genetta, 153, 156.
Genosema, 720.
 sexualis, 721.
 Geometridæ, 483, 484.
 Gillettia, 388.
 Glaucina, 488.
 erroraria, 487.
 escaria, 487.
 eupetheciaria, 487.
 maedunnoughi, 488.
 pygmeolaria, 487.
 Glossura, **544**, 546, 548, 549.
 Glyptopomus, 219.
 Gnypeta floridana, 730.
 Gomphognathus, 134, 135.
 Gonapsis, 369, 390, **391**, 400, 401.
 cuscuteformis, 391.
 potentillæ, 391.
 Gonodontis distycharia, 490.
 Gorgonopsidæ, 133.
 Græfia smithi, 489.
 Gregory, W. K., Studies in Comparative
 Myology and Osteology, No. IV.
 —A Review of the Evolution of the
 Lacrymal Bone of Vertebrates,
 with Special Reference to that of
 Mammals, 95–263; No. V.—On
 the Anatomy of the Preorbital
 Fossæ of Equidæ and other Un-
 gulates, 265–284.
 Grossouvria, 670.
 Gryposaurus, 107, 126, 127.
 Gundlachia, 550, 552.
 Gymnarthridæ, 102.
 Gymnura, 162–164.
 Gyrinophilus, 119.
 Gyrohypnus luteiventris, 704.
 temporalis, 704.
 Gyrophæna, 723.
 floridana, 719.
 lætula, 719.

HABROPODA, 577, **588**–591, 593.
 Halmæusa, 710, 711.
 Halmaturus, 143, 145.
Halterodon, see errata.
 Hapalemur, 204.
 Hapalops, 167, 168, 240.
 Haploceras fialar, 644.
 Haploconus, 180, 181.
 Harpagolestes, 148.
 Hatteria, 130.
 Hegetotheriida, 179.
 Hegetotherium, 108, 178, 179.
 Heleioporus, 443.
 Heleophryne, 443.
 Helochares, 14, 42, **61**, 62, 80, 81, 83, 86, 88.

- lividus, 8, 62.
 maculicollis, 8, 61, **62**, 65.
 normatus, 65.
 Helocombus, **56**, 62, 80, 81.
 bifidus, 8, 56.
 Helophorinæ, 17, 22, 80.
 Helophorus, 5, 11–17, 27, 28, 80–84, 87.
 aquaticus, 5, 18, **20**.
 granularis, 5, 17, 18.
 lacustris, 5, 17, **18**.
 linearis, 17.
 lineatus, 17.
 micans, 5.
 rufipes, 5.
 rugosus, 17.
 schmidti, 5.
 viridicollis, 5, 17.
 Hemesia, 544, 549–561, 568.
 Hemisentetes, 164.
 Hemigalago, 205.
 Heodes hypophlæas hypophlæas *banksi*,
 454.
 hypophlæas hypophlæas *fasciata*,
 454, 455.
 hypophlæas hypophlæas *fulliolus*,
 454.
 hypophlæas hypophlæas *obliterata*,
 454.
 xanthoides *luctuosa*, 453.
 Heptacodon, 191.
 Hesperobium cinctum, 701.
 Heterocentris, **550**, 553, 555, 568.
 Hilara, 726.
 fulviceps, 727.
 palleola, 727.
 Hipparion, 266, 268.
 Hippopotamidæ, 190, 191.
 Hippopotamus, 190.
 Hippotherium, 270, 271.
 Hister, 80.
 Holcaspis, 397, 398.
 globulus, 295.
 Holoptychius, 219.
 Homacodon, 186, 217.
 Homalodontotherium, 177.
 Homo, 109.
 Hoplandria, 720, 723.
 debilis, 721.
 lateralis, 719.
 ochracea, 719.
 pulchra, 719, 721.
 Hornia, 570, 576.
 Hyænidæ, 103, 156.
 Hyænodon, 147, 151, 218, 239.
 Hyænodontidæ, 147, 148, 208, 243.
 Hydræna, 15, **24**, 28, 78, 81, 82, 84.
 pennsylvanica, 6, 24.
 Hydræninæ, 21, 80.
 Hydriomena *clarki*, 483–485.
 furcata, 485.
 neomexicana, 486.
 speciosata, 485.
 Hydrobiinæ, 15, 22, **42**, 60, 80.
 Hydrobiini, 80, 82.
 Hydrobius, 12, 14, **51**, 66, 80–86.
 fuscipes, 4, 7, 12, 51, 52, **55**, 56.
 globosus, 7, 12, 51, **52**, 55, 58.
 scabrosus, 55.
 tessellatus, 55.
 Hydrocharis obtusatus, 4.
 Hydrochærinæ, 173.
 Hydrochærus, 109, 173, 174.
 Hydrochoinæ, 27, 80.
 Hydrochoini, 80.
 Hydrochous, 15, **27**, 28, 81–85.
 excavatus, 27.
 scabratus, 27, 28.
 squamifer, 6, 24, 27, **29**.
 Hydrophilidæ, 1–94.
 Hydrophilinæ, **31**, 35, 80.
 Hydrophilus, 3, 10, 14, 16, **31**, 35, 38,
 39, 81, 83, 85, 86, 88.
 caraboides, 6, 31.
 glacus, 33.
 obtusatus, 6, 15, **31**, 46, 86.
 Hydroscapha, 14, 15, 82, 84.
 natans, 4, 6.
 Hydroscaphidæ, 80.
 Hydroscaphinæ, 27, 80.
 Hydrous, 3, 9–11, 14, 31, 32, 35, **39**, 81,
 83, 85, 86, 88.
 aterrimus, 6, 39.
 piceus, 6, 39.
 triangularis, 4, 6, 15, 39, **40**, 41, 88.
 Hyla, 441.
 proselepon, 442.

- Hylella*, 441, 445.
 buckleyi, 442.
 ocellata, 442, 444.
 parambæ, 442, 444.
 tenera, 442.
Hylidæ, 443.
Hylodes anomalus, 441.
Hylonomidæ, 226.
Hyloplesion, 226.
Hyloscirtus, 443.
Hynnis alexandrinus, 285, 286, 290.
 cubensis, 285-289, 290, 292.
 gorensis, 285, 286, 288-291.
 hopkinsi, 285, 286, 290, 292.
Hypsoodontidæ, 175, 245, 246.
Hypsoodus, 175, 176, 215, 244.
Hyperodapedon, 129.
Hypocryptocerus, 430.
Hypohippus, 269, 270, 273, 278.
Hyptioma, 704.
Hyrachyus, 194, 195.
Hyracidæ, 185.
Hyracinæ, 185.
Hyracodon, 195, 196.
Hyracodontidæ, 195, 196.
Hyracodontinæ, 196.

IBALIA, 360.
Ichneumia, 152, 153.
Ictidopsis, 133, 134, 228, 232.
Ictops, 162, 240.
Idoceras, 643, 644, 669, 670.
Iguana, 228.
Iguanidæ, 130.
Iguanodon, 125.
Incisalia polios davisii, 453.
Indris, 205.
Indrisidæ, 203, 205, 209.
Indrisinæ, 203.
Interatheriidæ, 179.
Interatherium, 109, 179.
Ischyromyidæ, 173, 241, 242.
Ischyromys, 174.
Isæctolophus, 195.
Isocolus, 387.
Itame octolineata, 487.

KALOBATIPPUS, 269.

Keraterpeton, 226.
Kinsey, Alfred C., *New Species and Synonymy of American Cynipidæ*, 293-317; *Life Histories of American Cynipidæ*, 319-357; *Phylogeny of Cynipid Genera and Biological Characteristics*, 357*a-c*, 358-402.
Kogia breviceps, 161.
Kritosaurus, 126, 127.

LABIDOSAURUS, 121, 227, 230.
Laccobius, 14, 42, 43, 44, 71, 73, 79, 81, 83, 85, 87.
 agilis, 7, 43.
 minutus, 43, 46.
Lacerta, 98, 99, 107, 131.
Lagostomus, 471.
Lasius, 555, 561.
Latax, 109, 155, 156.
Lathrobiella ventralis, 702.
Lechriodus, 443.
Lemur, 109, 110, 200-205, 209, 215.
Lemuridæ, 201, 204, 206, 209.
Lemurinæ, 201.
Leonidia, 571.
Lepidosteidæ, 112.
Lepidosteus, 112, 220, 221.
Lepidotus, 220, 221.
Lepilemur, 203.
Leptadapis, 201, 202.
Leptergatis, 569, 587, 592, 593.
Leptictidæ, 109, 162, 163, 166, 240.
Leptodactylidæ, 441, 443.
Leptodactylus lineatus, 441.
 melanonotus, 441.
 mystaceus, 441.
Leptogenius brevicornis, 704.
Leptogenys puncticeps, 404.
Lepus, 174.
Licaphrium, 176.
Lichanotus, 205.
Limnebiinæ, 20, 22, 80.
Limnebiini, 80.
Limnebius, 14, 15, 21, 23, 78, 81, 82, 84.
 discolor, 5, 21.
 truncatellus, 5, 21.
Limnocyon, 146, 151.

- Limnoscelidæ*, 102, 121, 227.
Limnoscelis, 121, 227-229.
Linoglossa, 711.
Linolathra dimidiata, 702.
Liodes, 80.
Liposthenes glechomatia, 326.
Lispinus tenellus, 693.
 tenuis, 693.
Liposthenes, 387.
Lissagria, 731.
Lithocharis ochracea, 702.
Lithocharodes nigripennis, 704.
Lophagria, 730.
Lophiomys, 173.
Lophomucter, 720, 722.
 lævicollis, 722.
Lorinota, 731.
Loris, 205, 207.
Lorisidæ, 204, 205, 216.
Lorisinæ, 204.
Loxomma, 116, 118, 225.
Loxommatidæ, 116, 225.
Lutra, 109, 148, 155, 156.
 Lutz, Frank E., and Cockerell, T. D. A.,
 Notes on the Distribution and
 Bibliography of North American
 Bees of the Families Apidæ,
 Meliponidæ, Bombidæ, Euglossi-
 dæ, and Anthophoridæ, 491-641.
Lycosuchus, 134.
Lydekkerina, 225.
Lystrosaurus, 234.
Lytorhodites, 391, 392, 400.

MACARIA pictipennata, 486.
 simulata, 486.
 s-signata, 486.
Macrauchenia, 177.
Macrocera, 594, 597-599, 608, 610, 611,
 615, 625.
Macroglossa, 594, 622, 623.
Macroglossapis, 594, 622, 623.
Macromischa, 407-423.
 affinis, 407-410, 417.
 albispina, 408, 409, 424.
 albispina pallipes, 424.
 allardycei, 407-409, 414, 415.
 androsana, 407-409, 416.
 cressonia, 408.
 flavidula, 408, 424.
 flavitaris, 408, 410, 420.
 fuscata, 408, 410, 420.
 gundlachi, 408.
 iris, 408, 410, 422.
 isabellæ, 408, 409.
 lævissima, 408, 409.
 lucayensis, 408.
 lugens, 408, 410, 419.
 pastinifera, 407-409, 414.
 pastinifera opacipes, 407, 409.
 poeyi, 408.
 porphyritis, 408, 410, 413.
 pulchella, 408, 409, 424.
 punicans, 408, 418.
 purpurata, 408, 410, 411, 417.
 sallei, 407-409.
 sallei haytiana, 407, 409.
 salvini, 408, 410, 421.
 salvini obscurior, 410, 421.
 scabripes, 408, 409, 416, 417.
 schwarzii, 408, 415.
 splendens, 407, 408, 410, 417.
 squamifera, 408, 410, 417.
 squamifera atrinodis, 410, 413, 413.
 subdetiva, 408, 409.
 terricola, 408, 409, 423, 424.
 versicolor, 408, 421.
 wheeleri, 408, 410, 417, 423, 423.
Macropodidæ, 144.
Macropus, 108, 144, 267.
Macroscelides, 198, 199.
Macroscelididæ, 198, 199.
Manatidæ, 182.
Manatus, 182, 184, 216.
Manderstjernia, 394.
Manidæ, 170.
Manis, 107, 170, 171, 213.
 Mann, Wm. M., Additions to the Ant
 Fauna of the West Indies and
 Central America, 403-439.
Manteoceras, 197.
Manteoceratinæ, 197.
Marmosa, 139.
Martinella, 594, 605.
Mastodon, 109, 180, 183.
Mastodonsauridæ, 116, 225.

- Mastodonsaurus*, 101, 225.
Megaladapinae, 201.
Megaladapis, 201–203.
Megalichthys, 219.
Megalohyrax, 109, 184, 185, 216, 218.
Megalonychidae, 167.
Megalonyx, 166.
Megamys, 471.
Megilla, 554, 555, 561, 565, 580.
Melanerpeton, 114, 226.
Melanocentris, 550–561, 568.
Melecta, 576.
Meles, 154, 156.
Meliphila, 591.
Melipona, **493**–501.
 fasciata barticensis, 459, 460.
 fasciata costaricensis, 459.
 fasciata cramptoni, **459**, 460.
 fasciata panamica, 459.
 favosa, 460.
 intermixta, 460.
 interrupta oblitescens, 460, 463.
 lateralis, 460.
 lateralis lateralis, 461.
 lateralis intermixta, 461.
 lateralis kangarumensis, 461.
 oblitescens, 467.
 pseudocentris, 461.
 quadrifasciata, 460.
 quadrifasciata callura, 461.
Meliponidae, 492.
Melissoda, 595.
Melissodes, 539, 566, 567, 583–587, 591–594, **595**–627.
Melitoma, 591–593.
Meliturgopsis, 588, 593.
Melosaurus, 225.
Meniscotheriidae, 175, 245, 246.
Meniscotherium, 108, 175, 176, 245, 246.
Merychippus, 266, 269.
Meshippus, 193.
Mesoleuca interrupta, 486.
Mesonychidae, 103, 148, 208, 239.
Mesopiodon, 159, 161.
Mesopropithecus, 205.
Mesothoa viridipennata, 484.
Metachiromys, 168.
Metamynodon, 197, 279, 280.
Metopias, 225.
Metrocampa perlata, 489.
Miacidae, 103, 148, 149, 238.
Miacis, 239.
Micranthophora, 570–573, 575, 577, 581, 593.
Microbrachidae, 226.
Microbrachis, 226.
Microdota amicula, 727.
Microgale, 164.
Micropholidae, 115, 225.
Micropholis, 113–115, 223, 225.
Midas, 211.
Mioclaenidae, 245, 246.
Mioclaenus, 215.
Miohippus, 269, 270.
Mioxicebus, 204.
Mixtotherium, 186.
Mœritheriidae, 182, 245.
Mœritherium, 180, 182, 244, 245.
Mongos, 152, 156.
Monoclonius, 127.
Monomorium carbonarium ebeninum, 406.
 floricola, 406.
 stolli floridanus lucayanus, 406.
Moropus, 195.
Moschops, 132, 133.
Mus, 172.
Mustela, 153, 155, 156.
Mustelidae, 103, 154–156, 213.
Mycetes, 210, 211.
Mycocephalus smithi borinquensis, 430.
Mycterosaurus, 107, 122, 123, 227, 230.
Myllæna, 707.
 abditæ, 709.
 arcana, 708.
 audax, 709.
 brevicollis, 709.
 brevivestis, 709.
 cuneata, 708, **710**.
 currax, 708, **710**.
 decreta, 709.
 dissimulans, 708.
 dubia, 708.
 esuriens, 708.
 fenyesi, 709.
 frivola, 709.

- fuscipennis, 708.
 immunda, 709.
 impellens, 709.
 infuscata, 709, 710.
 insipiens, 707.
 insomnis, 708.
 intermedia, 708.
 ludificans, 709.
 minuta, 707, 708.
 molesta, 708.
 obscurata, 709.
 procidua, 708.
 scobinella, 709.
 umbra, 708.
 vegeta, 709.
 vulpina, 707, 708.
 Mylodontidæ, 168, 169.
 Myonycteris, 200.
 Myrmecobiinæ, 142.
 Myrmecobius, 142, 143, 171, 186, 207-
 209, 215, 217, 236.
 Myrmecophaga, 168, 169, 216, 218.
 Myrmecophagidæ, 108, 169.
 Myrmelachista ambigua ramulorum, 435.
 rogeri, 434.
 rogeri **rubricaps**, 434.
 Myrmeurynota, 435.
 Myrmicinæ, 405.
 Myrmobrachys, 435.
 Myrmoturba, 435.
 Mystriosuchus, 107, 125, 228.

 NAOSAURUS, 107, 122, 123, 227, 230.
 Nasua, 151.
 Necrolemur, 109, 204, 206.
 Necrolemuridæ, 204.
 Neobisnius umbripennis, 705.
 Neomoria festaria, 484.
 junctolinearia, 484.
 pistaciaria, 484.
 Nesodon, 177, 178.
 Nesomyrmex, 407.
 Nesophontes, 103, 163, 166, 208, 240.
 Nesopithecus, 207.
 Neuroterus, 342, 356, 358, 361, 368, 369,
 372, 375, 376, **394-396**, 400, 401.
 albipes albipes, 377.
 albipes lævisculus, 377.
 aprilinus, 396.
 aprilinus aprilinus, 378.
 aprilinus schlechtendali, 378.
 baccarum baccarum, 377.
 baccarum lenticularis, 377.
 batatus, **333**, 334, 365, 373.
 batatus batatus, 335, 377.
 batatus **bisexualis**, **334**, 377.
 catesbæi, 395.
 fumipennis fumipennis, 377.
 fumipennis tricolor, 377.
 notha, 350.
 noxiosus, **336**, 365, 373.
 noxiosus noxiosus, 338, 377.
 noxiosus **vernalis**, **337**, 377.
 numismalis numismalis, 377.
 numismalis vesicatrix, 377.
 pacificus, 334.
 quercus-batatus, 334.
 rileyi, 301.
 tectus, 338.
 tectus **abundans**, 339.
 tectus tectus, 339.
 thompsoni, 301.
 virgens, 395.
 Nichols, John Treadwell, *Hynnis* and
 Alectis in The American Museum
 of Natural History, 285-292; A
 Key to the Species of *Trachurus*,
 477-481.
 Noble, G. K., Two New Batrachians
 from Colombia, 441-444.
 Nothartina, 201.
 Nothartus, 100, 109, 200-202, 205, 207,
 209, 212.
 Nothodectes, 215.
 Notman, Howard, Staphylinidæ from
 Florida in the Collection of The
 American Museum of Natural
 History, with Descriptions of
 New Genera and Species, 693-732.
 Nycticebidæ, 204, 209.
 Nycticebus, 205, 207.
 Nyctosaurus, 128.
 Nylanderia, 431, 432.
 Nyrania, 225.

 OCHETOCERAS, 681.

- canaliculatum, 681-683, 686, 689.
 canaliculatum **burckhardti**, 681-686.
 mexicanum, 686-689.
Ochthebius, 14, 15, 21, 24, 25, 28, 81, 82, 84.
 foveicollis, 22.
 holmbergi, 21.
 impressus, 5, 21, 22.
 lejolisi, 21.
 punctatus, 5, 21.
 quadricollis, 5, 21.
 steinbuehleri, 5.
 steinbuhleri, 21.
 subinteger lejolisi, 5.
 tuberculatus, 5, 21, 22, 24.
O'Connell, Marjorie, The Jurassic Ammonite Fauna of Cuba, 643-692.
Octodon, 475.
Odobænidae, 157.
Odobæus, 157.
Odontomachus hæmatoda notata, 404.
 hæmatoda insularis pallens, 405.
 hæmatoda insularis ruginodis, 404.
 hæmatoda insularis wheeleri, 405.
Oligota parva, 710.
Omalium humerosum, 693.
Omoschema, 731.
 laticeps, 732.
Onhippidium, 266, 268, 275-278, 280, 282.
Onychodectes, 166, 167, 215, 421.
Ophiacodontidae, 102.
Ophioömma, 704.
 rufa, 705.
Opolemur, 206.
Oreodon, 193, 270.
Ornithorhynchidae, 139.
Ornithorhynchus, 137, 139, 234.
Ornithosuchus, 128.
Orthodiatelus, 714-716, 717.
 innotabilis, 716-718.
Orycteropodidae, 170.
Orycteropus, 108, 170, 171, 216, 218.
Osorius, 698.
 brevicornis, 698.
 latipes, 699.
 politus, 698.
Osteolæmus, 125.
Osteolepidae, 101.
Osteolepis, 111, 219.
Osteophorus, 225.
Otariidae, 156, 158.
Oxyænidae, 146.
Oxycænidae, 103, 146, 238.
Oxytrigona, 495.

PACHYRUKHOS, 108, 174, 178, 179.
Pæderus floridanus, 701.
 littoreus, 701.
 obliteratus, 701.
Palæanodon, 168, 215.
Palæohatteria, 129, 233.
Palæomastodon, 180, 245.
Palæoniscidae, 220.
Palæopropithecus, 205.
Palæoryctes, 163, 240.
Palæothentes, 108, 140, 145.
Palæothentidae, 140.
Palæotherium, 282.
Palaminus contortus, 701.
 testaceus, 701.
Paloplotherium, 282.
Pan, 201.
Pantolambda, 180, 243, 244.
Pantolestes, 165.
Pantylidae, 102, 120, 121, 227.
Pantylus, 102, 121, 227-230.
Paracymus, 14, 17, 28, 42, 51, 74, 81-88.
 æneus, 7.
 subcupreus, 7, 24, 58, 71, 74.
Parahippus, 269.
Paramys, 172-174, 242.
Parasilusa, 711.
Pariasauridae, 101, 120, 121, 227.
Pariasaurus, 120, 121, 227, 228, 230.
Pariotichidae, 102.
Patriocetus, 160.
Patriofelis, 239.
Pectusa, 711, 717.
Pedetes, 173, 174.
Pedetidae, 173.
Pediaspis aceris aceris, 379.
 aceris sorbi, 379.
Pelosaurus, 223-226.
Peltoceras bimamatum, 689.

- transversarium, 673, 675, 686.
 Pelycodus, 202.
 Peponapis, 614, **623-626**.
 Perameles, 140, 143.
 Peramelidæ, 108, 140.
 Perchœrus, 108, 191, 193.
 Periclistus, 358.
 Periptychidæ, 181, 243, 246.
 Perisphinctes, 644, **646**, 647, 669, 670.
 alterniplicatus, 680.
 cubanensis, 646, **648-663**, 667, 668, 677, 778.
 cubanensis *a*, **660-663**.
 cubanensis *β*, **662-663**.
 delatorii, **663-670**.
 durangensis, 660.
 healeyi, 671-674.
 orbigny, 670-674-679.
 plicatilis, 670-680.
 plicatiloides, 646, **670-680**.
 Perisphinctinæ, 644, 645, 658.
 Perodicticus, 109, 204.
 Phacochœrinæ, 192.
 Phacochœrus, 192, 193, 216, 218.
 Phænonotum, 77, 81, 83, 87.
 Phæoura mexicanaria, 489.
 Phalangista, 108, 145.
 Phanacis, 358, 369, 400, 401.
 centaureæ, 297, 388.
 Phascolarctos, 108.
 Phascolomyidæ, 144.
 Phascolomys, 108, 144, 145, 216.
 Phasiane tenebrosata, 487.
 Pheidole androsana, 426.
 androsana bakeri, 426.
 cubaensis **grayi**, 426
 fallax, 426.
 flavens, 427.
 flavens asperithorax, 427.
 flavens asperithorax semipolita, 427.
 punctatissima, 427.
 punctatissima annectens, 427.
 Phenacodontidæ, 175, 245, 246.
 Phenacodus, 108, 175, 176, 245, **246**.
 Philonix, 294, 320.
 compressa, 352, 353.
 erinacei, 355.
 fulvicollis, 355, 356.
 hirta, 365.
 pezomachoides, 365.
 Philonthus alumnus, 706.
 flavolimbatus, 706.
 fulvipes, 706.
 gopheri, 706.
 hepaticus, 705.
 lomatus, 706.
 Philotes enoptes **mojave**, 455.
 sonorensis **sonoralba**, 456.
 Philydrus, 14, 56, 58, 62, 63, **65**, 76, 80-83, 86, 88.
 cinctus, 8, 56, 65, 70.
 consors, 65. .
 hamiltoni, 8, 65, 70.
 nebulosus, 8, 65; **66**, **69**, 70.
 ochraceus, 8, 65, 70.
 perplexus, 8, 65-**67**, **69**, 70.
 testaceus, 8, 65,
 Phlaocyon, 150, 151.
 Phoca, 158.
 Phocidæ, 107, 158, 213.
 Phymatura, 713.
 Physeteridæ, 161.
 Physeterinæ, 160.
 Pigia multilinea, 484.
 Pinophilus latipes, 701.
 Placochelys, 99.
 Plagiaulacidæ, 138.
 Plagiomene, 248.
 Plateomys, 475.
 Platandria, 720.
 Platanistidæ, 160.
 Platonica, 720.
 Platyrrhinæ, 110, 210-212.
 Platysomidæ, 220.
 Platythyrea punctata, 404.
 Plebeius acmon **labacula**, 457.
 Plesiadapidæ, 199, 248.
 Pleuraspidotheriidæ, 245.
 Pleurosaurus, 129, 233.
 Pliohippus, 268, 269.
 Podalirius, 555, 561, 570-582, 588-592.
 Podophyra, 11.
 Pœcilocentris, **560**, 553, 557, 568.
 Poliosauridæ, 102, 122, 227.
 Polymastodon, 107, 137, 138.
 Polypteridæ, 112.

- Polypterus*, 101, 112, 113, 219, 220.
Ponera opaciceps, 404.
Ponerinae, 404.
Potamochoerus, 192, 266, 267, 270.
Potamogale, 107, 164-166.
Potamogalidae, 165.
Prenolepis anthracina, 433, 434, 431, 432.
 gibberosa, 403, 433.
 gibberosa rogeri, 434.
 guatemalensis antillana, 431.
 myops, 432.
 pyramica, 431.
 steinheili, 431.
 vividula antillana, 431.
Procamelus, 187, 193.
Procavia, 186.
Procolophon, 107, 119, 121, 217, 227-230.
Procolophonidae, 102, 121, 227.
Procyon, 150, 151.
Procyonidae, 103, 149, 150, 151.
Prodasypus, 168.
Proechimys, 472.
Propithecus, 109, 203, 205.
Prosimia, 206, 207.
Protapirus, 195.
Proterix, 162, 163.
Protheroitheriidae, 175.
Protocetus, 158, 243.
Protohippus, 269.
Protriton, 226.
Protylopus, 193.
Protypotherium, 109, 179.
Prozeuglodon, 159, 160.
Pseudaulax, 385.
Pseudolathra analis, 702.
Pseudomyrma elongata, 405.
 elongata cubaensis, 405.
 flavidula, 405.
 flavidula pazosi, 406.
 pazosi, 406.
Psiloceras planorbe plicatum, 667.
Psithyrus, 502, 505, 507, 510, 516, 517, 521, 522, 533, 539-544.
Psittacotherium, 166, 215.
Psylliodes, 17.
Ptilocercus, 199.
Ptilodus, 234, 235.
Ptilothrix, 587.
Ptilotopus, 550-561, 568.
Pyramica gundlachi, 430.
Python, 107.

RANA, 118.
Ranidae, 118.
Ranodon, 119.
Rhinoceros, 196, 272, 276, 279, 281.
Rhinocerotidae, 194, 196.
Rhinochoerus, 276.
Rhizodopsis, 219.
Rhodites, 357c, 358, 359, 461, 368-371, 375, 376, 385, 390, 391, 400, 401.
 arefactus, 391.
 bicolor, 371, 393.
 carolina, 331.
 carolinus, 331.
 dichlocerus, 366, 371.
 eglanteriae, 393, 394.
 fulgens, 391.
 fusiformans, 393.
 globuloides, 331.
 ignota, 331.
 ignotus, 331-333, 371, 394.
 mayri, 328.
 multispinosus, 391.
 nebulosa, 393.
 nebulosus, 391, 393.
 neglectus, 391.
 nodulosus, 294, 392.
 ostensackeni, 391.
 rosae, 328-332, 371, 382, 392-394.
 semipiceus, 391.
 spinossissimae, 394.
 verna, 294.
 vernus, 294, 392, 393.
Rhodocentris, 550-560, 568.
Rhoophilus loewi, 365.
Richmond, E. Avery, Studies on the Biology of the Aquatic Hydrophilidae, 1-94.
Rhynchocyon, 109, 198-200, 217, 266-268, 282.
Rhynchosaurus, 233.
Rhytina, 184.

SACCOLAIMUS, 200.

- Saghatheriinae, 185.
 Salamandridae, 117, 213.
 Salamandrina, 117, 223.
 Salpa, 323.
 Santhota, 731.
 Sarcophilus, 142, 143, 145.
 Saropoda, 589.
 Sauranodon, 129, 233.
 Sauravidae, 101.
 Scaphognathus, 128.
 Scelidotherium, 168, 169, 240.
Schistacme obtusa, 711, 712.
 Sciagraphica colorata, 486.
 Scincosaurus, 226.
 Sciocharella, 703.
 Sciocharis **quadriceps**, 703.
 Sciuroidae, 173.
 Sclerocephalus, 225.
 Scomber trachurus, 479.
 Scopæopsis opaca, 703.
 Scopeus carolinæ, 703.
 macilentus, 703.
 Scylacops, 107, 133, 227.
 Scyris alexandrina, 285, 289.
 indica, 285, 286, 292.
 Selene, 291.
 vomer, 286.
 Seironota, 117.
 Seriola picturata, 480.
 Seymouria, 120, 121, 227, 228.
 Seymouriidae, 101, 120, 121, 227.
 Silphidae, 80.
 Silusa, 711.
 Silusæ, 710.
 Silusida, 713, 714.
 tenuicornis, 714.
 Simiidae, 210.
 Simocephalus, 11.
 Simosaurus, 99.
 Solenodon, 163-165, 208.
 Solenodontidae, 165.
 Solenopsis corticalis **binotata**, 428.
 corticalis virgula, 428.
 geminata, 427.
 globularia **desecheoensis**, 428.
 leviceps, 427.
 Solenozopheria vaccinii, 365.
 Sorex, 165, 166, 208.
 Spaniopone, 407.
 Spathegaster, 394.
 quercus-laurifoliae, 350.
Speoxenus cundalli, 473, 474.
 Spercheus, 14, 79, 81-84.
 Sperchinae, 80.
 Sphæridiinae, 77, 80, 82.
 Sphæridium 15, 77, 81, 83, 87, 88.
 Sphenacodon, 107, 122, 227, 230.
 Sphenacodontidae, 102, 122, 227.
 Sphenodon, 99, 107, 130, 228-230, 233.
 Sphenodontidae, 130.
 Sphercheinae, 30, 80.
 Sphyræna, 112.
 Sphyrænidae, 112.
 Spilogale, 109, 155.
Spirodontomys jamaicensis, 473, 474.
 Squalodontidae, 161.
 Stannoderus pallidus, 703.
 Staphylinidae, 78, 80, 693-732.
 Stegochelys 119, 230.
 Stegopidae, 115, 225.
 Stegops, 115, 223.
 Stegosaurus, 127.
 Stegotherium, 167, 168, 171.
 Stenagria, 731.
 Stenaspilates albomacularia, 490.
 flavisaria, 490.
 levisaria, 490.
 Stenometopon, 129, 233.
 Stenus, 699.
 callosus, 700.
 lutsi, 700.
 meridionalis, 700.
 sectilifer, 700.
 teter, 699.
 Stephanoceras, 670.
 Stephanoceratidae, 670.
 Stephanosaurus, 127, 128.
 Stergamataea dolliata, 489.
 Stilicus angularis, 703.
 Strumigenys alberti, 340.
 eggersi **cubaensis**, 430.
 eggersi vicentensis, 430.
 margaritæ, 430.
 rogeri, 430.
 Strymon acadica acadica **muskoka**, 450.
 acadica **coolinensis**, 451.

- acadica montanensis*, 451.
acadica souhegan, 449.
acadica souhegan swetti, 450.
chalcis, 453.
sæpium, 452.
sæpium chlorophora, **452**, 453.
sæpium fulvescens, 453.
sæpium provo, 452.
Subhyracodon, 196.
Suidæ, 192, 193, 266, 268, 282.
Suinæ, 192.
Sus, 100, 193, 272.
Synalonia, 614, 615.
Synchlora liquoraria, 484.
Synergus, 358.
 lignicola, 295.
Synglochis perumbraria, 488.
Synhalonia, 580, 608, **614**–622, 626, 627.
Systemodon, 195, 248.

TACHYPORUS macropterus, 706.
Talpa, 165, 166, 208.
Tamandua, 169, 170.
Tanygnathus bicolor, 706.
Tapinocephalidæ, 132.
Tapinoma litorale, 431.
 litorale cubaensis, 431.
Tapiridæ, 194, 195.
Tapirulus, 186.
Tapirus, 194, 272, 275, 276, 280.
Tarpon, 112.
Tarsiidæ, 204, 216.
Tarsius, 109, 204, 206, 209, 212.
Tatusia, 168.
Taxidea, 154, 156.
Tayassu, 191.
Teleosaurus, 125.
Tatartopeus nigriceps, 702.
Tetonia, 204, 206.
Tetrachodon, 245.
Tetragona, 463, 493, **495**.
Tetrallus, 719.
Tetralonia, 580, 594, 595, 598–608, 612,
 614–624, 627.
Tetraloniella, 622, 626.
Tetramorium guineense, 407, 413.
 lucayanum, 406.
 simillimum, 406.

Tetrapedia, 562, **568**, 569.
Tetrastylus, 471.
Tharsalea virginiensis, 452.
Thecla, 449.
Thecturota fracta, 713.
 nevadica, 713.
Theosodon, 176.
Thinocyon, 146, 151.
Thoatherium, 176.
Thoracophorus costalis, 693.
Thygaster, 594, 597, 607, 611, 616.
Thylacinus, 134, 142, 145, 218.
Thryptacodon, 238.
Tillotherium, 103, 171.
Timaspis, 358, 361, 369, **387**, 400, 401.
Tinotus, 719, 723.
 amplus, 723.
 brunnipes, 724.
 parvicornis, 725.
 planulus, 724.
Tolypeutes, 167.
Tomistoma, 125.
Tomoxelia, 711.
Tornos erectarius, 487.
 scolopacinaris, 487.
Toxodon, 178.
Toxodontidæ, 177.
Trachina, **549**, 555–560, 569.
Trachodon, 127.
Trachodontidæ, 126.
Trachurus capensis, 479, 480.
 cuvieri, 478.
 declivis, 477–**480**, 481.
 japonicus, 477–**479**, 480, 481.
 lathamii, 478, **479**.
 linnæi, 478.
 mccullochi, 478, **479**–481.
 mediterraneus, 477–**479**, 480.
 murphyi, 478, **479**–481.
 novæ-zelandiæ, 477, 478, 480.
 picturatus, 478–**480**, 481.
 semispinosus, 478, **479**, 480.
 symmetricus, 477–**480**, 481.
 trachurus, 478, **479**, 481.
Trachymesopus, 404.
Trachymyrmex, 428.
Tragulidæ, 187.
Tragulus, 187.

- pedition to Arizona, 1916, 483-490.
Wynyardia, 107, 143, 144, 236.
XENOGLOSSA, 558, 574, 593, 597, 599, 602, 611-619, **623**-626.
Xenoglossodes, 565, 597, 610, 617, 620, 622, **626**.
Xenomymex, 406.
ZETHUS, 547.
Zeuglodon, 158.
Zeuglodontidæ, 159.
Zeus ciliaris, 292.
Ziphiidæ, 159.
Ziphiinæ, 160, 161.
Ziphius, 161.



PUBLICATIONS

OF

THE AMERICAN MUSEUM OF NATURAL HISTORY

MEMOIRS

Volume I. Zoology and Palaeontology.
Volumes II-VIII. Anthropology.
Volume IX. Zoology and Palaeontology.
Volumes X-XIV. Anthropology.
Volumes II, IV, V, VII, VIII, X-XIV, and an Ethnographical Album form
Volumes I-X of the Memoirs of the Jesup North Pacific Expedition.

MEMOIRS—NEW SERIES

Volumes I and II. Zoology and Palaeontology.
Volume III, part 1. Entomology.
Volume III, parts 1 and 2. Palaeontology.

BULLETIN

Volumes I-XXIV, XXV, parts 1 and 2, and XXVI-XLII.

ANTHROPOLOGICAL PAPERS

Volumes I-XI; XII, parts 1-5; XIII; XIV; XV, part 1; XVI, parts 1-5;
XVII, parts 1-4; XVIII; XIX, parts 1-4; XX, part, 1; XXI, parts 1-2; XXII,
parts 1-4; XXIII, parts 1-3; XXIV, parts 1-3; XXV, part 1; XXVI, part 1.

MONOGRAPHS

A Review of the Primates. By D. G. Elliot. 3 volumes.
Hitherto Unpublished Plates of Tertiary Mammals and Permian Vertebrates.
By E. D. Cope and W. D. Matthew.

THE AMERICAN MUSEUM JOURNAL

Volumes I-XX. The Journal is a popular record of the progress of The American
Museum of Natural History, issued bimonthly.

HANDBOOKS. Numbers 1-8.

GUIDE LEAFLETS. Numbers 1-51.

ANNUAL REPORTS. First (1869) to Fifty-second (1920).

A more detailed list, with prices, of these publications may be had upon applica-
tion to the Librarian of the Museum.



3 2044 093 305 258

DOES NOT CIRCULATE

